This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

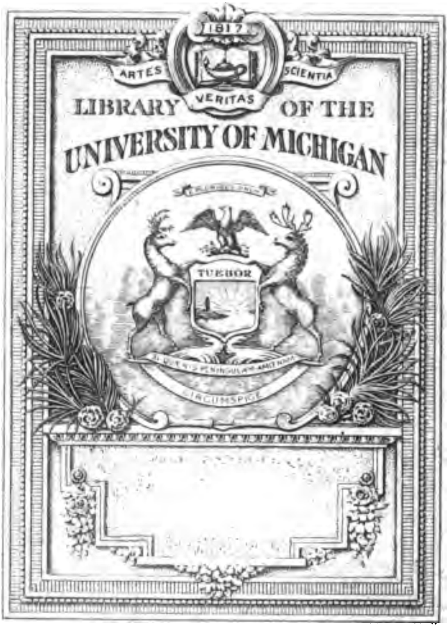
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

B 469684 DUPL


LIBRARY OF THE
UNIVERSITY OF MICHIGAN

1817
ARTES VERITAS SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN

Astronomical
C[illegible]

QB
82
.U58

REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30, 1904.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1904.

NU

Astronomy

REPORT

OF

THE SUPERINTENDENT OF THE NAVAL OBSERVATORY.

UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., July 1, 1904.

SIR: I have the honor to submit the annual report of the operations of the United States Naval Observatory for the fiscal year ending June 30, 1904:

PLAN OF WORK.

The plan of work was laid out at the beginning of the year on the broad ground as contemplated by the law and the instructions of the Department, and has in the main been continued as then specified in the Superintendent's order which was prepared, after mature consideration of the probabilities of the period covered by this report, by the plan of work committee, of which the Superintendent is the chairman.

PERSONNEL.

The following changes among the officers and employees have occurred since the last report:

Commander J. M. Robinson, U. S. Navy, reported for duty August 10, 1903.

T. I. King was transferred from assistant astronomer, department of astronomical observations, to piecework computer, department of the Nautical Almanac, November 24, 1903.

John C. Hammond was promoted from computer to assistant astronomer November 24, 1903.

F. E. Millis, assistant, died August 1, 1903.

H. B. Evans was promoted from assistant at $1,000 per annum to assistant at $1,200 per annum, August 12, 1903.

A. B. Turner was promoted from miscellaneous computer to computer April 28, 1904.

J. R. Benton, miscellaneous computer, was transferred to the Bureau of Standards July 1, 1903.

Arthur Snow was appointed typewriter September 21, 1903, and promoted to assistant at $1,000 per annum, June 13, 1904.

Charles N. Moore was appointed miscellaneous computer October 3, 1903.

Alice M. Gray was appointed miscellaneous computer October 22, 1903.

Jesse Pawling, jr., was appointed miscellaneous computer October 26, 1903.

Ella A. Merritt was appointed miscellaneous computer December 28, 1903.

Florence A. Graves was appointed miscellaneous computer December 28, 1903.

Matt Frederickson was appointed miscellaneous computer March 30, 1904.

Perez Fisch was appointed miscellaneous computer April 8, 1904.

Arthur Newton was appointed piecework computer June 20, 1904.

L. A. Richards was appointed temporary miscellaneous computer January 28, 1904, and again appointed May 31, 1904.

Stephen F. McMahon, fireman, resigned July 15, 1903.

Ben Wheeler was appointed fireman October 9, 1903.

V. Muehlhaus, jr., was transferred from watchman to laborer June 1, 1904.

E. M. Rowe was transferred from laborer to watchman June 1, 1904.

H. C. Lemon, laborer, resigned April 7, 1904.

Herbert S. Murdoch was appointed laborer April 8, 1904.

C. S. Thomas, messenger boy, resigned March 13, 1904.

J. H. Nelson was appointed messenger boy April 1, 1904.

Mr. William Henderson, watchman, died May 21, 1904, after several weeks' illness. He was born in Scotland in 1846, and was for thirty-six years an employee of the Naval Observatory, first as a laborer, from 1868 to 1882, then as a watchman to the date of his death.

Mr. Henderson enlisted in the United States Army at the outbreak of the civil war, and was wounded in the battle of Fredericksburg, Va. On the expiration of his enlistment he reenlisted and served until the close of the war. His father, also a Union soldier, was killed by his side in the battle of Fort Fisher.

Mr. Henderson's services to the Naval Observatory have been of much value. For many years, in addition to his duties as a watchman, he took part in keeping the meteorological journal of the Observatory, and his faithful attention to duty has added to its prestige as one of the oldest and most complete meteorological records in the Government service. His personal character has been one for emulation, and the Observatory and his associates will feel his loss for many years.

ORGANIZATION.

Slight changes have been made in the organization of the Observatory as experience has dictated, and it stands at present as prescribed by the Regulations of the United States Naval Observatory issued by the Department January 25, 1904, as follows:

OFFICE OF THE SUPERINTENDENT.

Clerk, Thomas Harrison; stenographer, Mrs. A. P. R. Auhagen.

ASTRONOMICAL BRANCH.

A. *Department of astronomical observations.*—Division of equatorial instruments (26-inch and 12-inch equatorials): Professor of Mathematics A. N. Skinner, in charge; Assistant Astronomer J. C. Hammond, Assistant on Equatorial C. W. Frederick, Assistant in Spectroscopic Work W. W. Dinwiddie.

Division of meridian instruments (9-inch and 6-inch transit circles): Professor of Mathematics W. S. Eichelberger, in charge; Assistant Astronomer H. L. Rice, and Computers W. M. Brown, E. I. Yowell, and H. R. Morgan.

Division of the alt-azimuth instrument: Professor of Mathematics F. B. Littell, in charge.

Division of the prime vertical transit instrument: Assistant Astronomer G. A. Hill, in charge.

The Photoheliograph: Photographer G. H. Peters, in charge.

Librarian W. D. Horigan.

Computers for the department: Computers Eleanor A. Lamson and A. B. Turner, and Miscellaneous Computers Etta M. Eaton, Alice M. Gray, Florence A. Graves, Ella A. Merritt, Perez Fisch, and Matt Frederickson.

The miscellaneous computers have been changed from time to time as candidates became available, the appropriation of $4,000 for miscellaneous computations providing for an average of four computers.

B. *Department of the Nautical Almanac.*—Professor of Mathematics Walter S. Harshman, director; Assistants H. B. Hedrick, W. Auhagen, J. Robertson, H. G. Hodgkins, J. H. Root, G. B. Merriman, W. T. Carrigan, H. B. Evans, E. D. Tillyer, and Arthur Snow, and Piecework Computers R. Buchanan, Mrs. E. B. Davis, A. Doolittle, Mrs. H. F. M. Hedrick, R. Keith, Janet McWilliam, T. I. King, and A. Newton.

NAUTICAL BRANCH.

A. *Department of nautical instruments.*—Commander J. M. Robinson, in charge; Clerk E. A. Boeger, acting assistant.

B. *Department of chronometers and time service.*—Lieut. Commander E. E. Hayden, in charge; Miscellaneous Computer C. N. Moore, acting assistant.

C. *Department of magnetism.*—Photographer G. H. Peters, temporarily in charge.

PUBLICATIONS.

During the fiscal year ending June 30, 1904, Volume V, Publications of the United States Naval Observatory, Second Series, has been issued.

As showing the contributions to astronomy in general other than that shown in governmental publications, the following list of articles made public is submitted:

In Cassier's Monthly, May, 1904: "Scientific work of the Navy," by Rear-Admiral C. M. Chester, U. S. Navy, Superintendent.

In the Proceedings of the United States Naval Institute, Vol. XXIX, No. 3: "Chronometer rates," by Lieut. Commander E. E. Hayden, U. S. Navy.

In Popular Astronomy, August–September, 1903: "A method of obtaining the focal point of a lens of long focus," by G. A. Hill.

In the Astronomische Nachrichten, Nr. 3806: "Recent observations of the declination of Groombridge 1830," by G. A. Hill.

In the Astronomical Journal, Nos. 542–543: "Observations of minor planets," by J. C. Hammond; "Observations of the satellite of Neptune," by W. W. Dinwiddie; "Observations of comet *d* 1902

(Giacobini)," by W. W. Dinwiddie; "Observations of comet *b* 1902 (Perrine)," by C. W. Frederick.

In the Astronomical Journal, No. 545: "Elements and ephemeris of comet *c* 1903 (Borrelly)," by H. R. Morgan and Eleanor A. Lamson.

In the Astronomical Journal, No. 546: "Observations of comet *c* 1903 (Borrelly)," by T. I. King.

In the Astronomical Journal, No. 547: "Observations of minor planets," by J. C. Hammond; "Observations of Brooks's comet (1889 V)," by C. W. Frederick.

In the Astronomical Journal, No. 551: "Error in the planet (15) Eunomia in the Jahrbuch for 1905," by J. C. Hammond and W. W. Dinwiddie.

In the Astronomical Journal, No. 552: "Observations of comet and minor planets," by T. I. King; "The instrumental constants in equatorial work," by C. W. Frederick.

In the Astronomical Journal, No. 554: "Observations and circular elements of planet (1898 DW)," by W. W. Dinwiddie.

In the Astronomical Journal, No. 555: "Observations of the satellites of Uranus," by W. W. Dinwiddie.

In the Astronomical Journal, No. 556: "Observations of minor planets," by W. W. Dinwiddie; "Observations of minor planets," by C. W. Frederick.

In the Astronomical Journal, No. 558: "Observations of minor planets," by J. C. Hammond; "Observations of Brooks's comet (1889 V) =*d* 1903," by C. W. Frederick.

In the Astronomical Journal, No. 559: "Observations of the satellites of Saturn in 1903," by C. W. Frederick.

In the Astronomical Journal, No. 561: "Observations of comet *a* 1904 (Brooks)," by J. C. Hammond; "Elements and ephemeris of comet *a* 1904 (Brooks)," by Everett I. Yowell.

In the Astronomical Journal, No. 562: "Observations of comet *a* 1904 (Brooks)," by J. C. Hammond; "Elements and ephemeris of comet *a* 1904 (Brooks)," by Everett I. Yowell; "Observations of minor planets," by W. Walter Dinwiddie.

In the Astronomical Journal, No. 563: "Note on a probably new minor planet," from a letter of Rear-Admiral C. M. Chester; "Ephemeris of comet *a* 1904 (Brooks)," by Everett I. Yowell.

In the Astronomical Journal, No. 564: "Provisional elements of the minor planet (1904 NY)," by J. C. Hammond; "Photographic positions of minor planets," by G. H. Peters.

In Harper's Weekly, December 19, 1903: "Photographing the Sun," illustrated, by George H. Peters.

In Popular Astronomy, June–July, 1904: "Elements and ephemeris of comet *a* 1904 (Brooks)," by Everett I. Yowell.

The following paper was read by Professor Eichelberger before the Astronomical and Astrophysical Society of America, St. Louis meeting, 1903–4: "The pivots of the 9-inch transit circle of the United States Naval Observatory."

The following article has been communicated to the United States Naval Institute for publication: "Work of the Naval Observatory," by Rear-Admiral C. M. Chester, U. S. Navy, Superintendent.

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

DIVISION OF EQUATORIAL INSTRUMENTS.

From the schedule of organization it will be seen that the charge of the two equatorial instruments has been placed under one head, which permits a more harmonious distribution of the work between the observers and a more economical use of their time. Observations of an occasional character, such as those of comets, etc., can be doubled if necessary or given to the instrument that can best be spared for them or is the more suitable for the purpose. Being engaged on observations of a similar character the observers can by this arrangement be the more readily transferred from one instrument to the other in case either instrument is undergoing repairs. Professor Skinner has succeeded in getting the best results from the combination.

The 26-inch equatorial has remained in the efficient condition reported at the end of the previous year, and its utility has been considerably increased by devoting more time than formerly to the location of asteroids. The attachment of the Dallmeyer camera to the telescope has enabled Mr. Peters, the photographer of the Observatory, to establish the identity of a number of asteroids by photography, thereby saving much of the time that was given to the laborious and often ineffectual visual method. Such observations, which usually require an exposure of photographic plates of about an hour, enable the astronomer to distinguish the images of fixed stars, which show as dots, from those of members of the solar system, which are indicated by trails. The positions thus approximately determined are then given to the observers on the equatorial instruments, who with the telescope and the micrometer obtain accurate positions of these heavenly bodies. The report of Professor Skinner shows what a large contribution of asteroid observations has been made to astronomical science during the past year through the untiring efforts of Messrs. J. C. Hammond, G. H. Peters, and W. W. Dinwiddie. A quotation subsequently made from a letter received from the eminent astronomer Dr. S. C. Chandler will testify to the appreciation of their efforts by the astronomical world.

But it is not abstract science alone that is advantaged by this interesting study of asteroids, for it has a direct bearing and application to the theory of planetary motion, which forms an important part in the preparation of the Nautical Almanac for which the Observatory was designed.

Owing to the extreme faintness of many of the asteroids that have demanded investigation, it is only by means of the largest instruments that these can be observed, and indeed some of them are so excessively faint as to elude detection altogether. It was for the purpose of observing very faint objects, especially the delicate work of determining the positions of the numerous satellites of the major planets, that Congress appropriated the money for the purchase of the 26-inch equatorial, the installment of which brought to the Observatory a large portion of its prestige and to Prof. Asaph Hall, U. S. Navy (retired), his fame as the discoverer of the satellites of Mars.

As this instrument is still one of the largest equatorials in the world, it seems eminently proper that it should be employed with effect in giving to navigational astronomy the factors which enter into the problem of the masses of the planets and hence their motions in space. As there are but few observatories engaged in the study of asteroids, astronomers have been led to fear that some of the vast group of known minor planets—now numbering something over 500—may be lost. The perturbations in their orbits create difficulties in the solution of the problem, and unless the larger observatories retain their hold on them, as the Naval Observatory is doing, their fears may be realized.

Mr. C. W. Frederick has during the year, in addition to routine work, contributed a valuable investigation on constants of equatorials that has been well received by the astronomical people of the country.

The 12-inch equatorial is not in as good a condition as I could wish, and while it is hoped that improvements can be made, the clock mechanism, if not entirely reconstructed, is likely to continue a factor of weakness. One of the drawbacks to the output of work with this instrument is that it is used regularly by the public on one night of each week, and on additional special evenings in order to accommodate the large number of scholars in the District of Columbia who are studying astronomy. Mr. Peters has taken charge of the visitors admitted by permit during the past year, and he has by his explanations of the objects shown through the telescope made the evenings interesting and instructive.

In addition to the care of this division of the department of astronomical observations and his duties as an observer, Professor Skinner has continued to devote a large amount of time to the preparation of the catalogue of the Astronomische Gesellschaft Zone, which covers the section of the heavens between 13° 50′ and 18° 10′ south declination, a contribution which the Observatory agreed several years ago to make to the material for a general catalogue of the stars to the ninth magnitude.

DIVISION OF MERIDIAN INSTRUMENTS.

The division of meridian instruments has remained in the charge of Professor Eichelberger, and his administration is commended.

In addition to the repairs on the 9-inch transit circle, which have put the instrument in first-class condition, a south meridian mark has been mounted. This, in conjunction with the north mark, affords a determination of the collimation independent of the collimators and greater accuracy in the determinations of the azimuth.

The work of this division includes the determination of the right ascension and declination of the sun, moon, and planets, the stars of Newcomb's Suggested List of Fundamental Stars, and others that are required for Nautical Almanac purposes.

In laying out the work of this division for the year it became apparent that while two good instruments were available—the 6-inch and 9-inch transit circles—better results would accrue by concentrating the limited number of observers on the 9-inch transit circle, which was just in from the repair shop, where it had been for nearly two years, and leaving the 6-inch transit circle for such incidental work as might be called for. The great advantage of concentrating the observers upon one instrument is the saving of the time that would be necessary for the determination of a second set of constants, which time can be devoted to obtaining additional observations.

The excellent record of this division, having nearly 12,000 observations to its credit, a larger number than was ever obtained before at the Observatory in any one year, even when both instruments were in use, shows the wisdom of the arrangement considering the number of observers available. If a suitable force is given the Observatory to complete the reductions of the observations made, another fact, that the arrangement is conducive to the saving of time in making the reductions, will also be demonstrated.

The clock system of the Observatory, upon which all our right ascensions depend and upon which so much time has heretofore been expended, has during the year been given serious attention. One of my first duties as Superintendent of the Observatory was to purchase from Clemens Riefler, of Germany, one of his best clocks. These clocks are the exponent of the most advanced thought and inventions of the age, but they must be manipulated with intelligence and painstaking care, or they become valueless. After this clock was set up and adjusted in the clock vault Professor Eichelberger and Mr. Cleve, the instrument maker, gave it their constant attention. One difficulty after another was met and overcome, but there are apparently inherent faults in the mechanism of the electric winding which only the makers can remedy, and it has been returned to Riefler for correction.

Soon after the Observatory clock was purchased the Bureau of Equipment purchased four other clocks of a similar character from the same maker. One was sent direct to the naval station at Cavite, Philippine Islands, and another has been shipped to Sitka, Alaska. By the Bureau's direction the other two, one intended for Tutuila and one for Guam, were received at the Naval Observatory for test and adjustment. The Guam clock has been set up in the clock vault and the Tutuila clock in the clock room. Thus the Observatory has been provided for the time being with three of the most modern clocks known to the profession. These have all contributed to our knowledge of clock mechanism, and' Professor Eichelberger's persistent efforts to get them into the most efficient condition is most creditable.

The work formerly done in a computing division is now carried on under the general supervision of the committee on editing and printing, with the head of the division of meridian instruments as member and secretary. This plan is naturally suggested, as the amount of reductions in the division of meridian instruments greatly exceeds that in all the other divisions, while it brings into cooperation all the heads of divisions in arranging the work in harmony with the various interests.

A demand has long existed for a catalogue from the Washington Zone observations made at this Observatory in the early years of its existence, and this work has been taken up from time to time, only to be dropped in order that the small force might keep up with the current work. A moral obligation rests on the Observatory to publish this data in a completed form for the benefit of science, and it is hoped that it may not again be necessary to entirely drop it from the routine work of the Observatory until its final completion.

The publications of the Observatory have followed each other in rapid succession since the beginning of the century. During the few years immediately preceding 1900, when no Observatory volumes were issued from the press, the entire time of the computing force was devoted to the reduction of observations. The use of a portion of the computing force in preparing copy for the printer and in reading the proof incident to the issue of the Observatory volumes, as is now necessary, lessens the amount of computing done. Further, the reduction of a single month's observations of the past year could not be completed by the existing force in several months' time. In consequence of the necessities due to printing and of the large number of observations accumulating the current work is falling rapidly into arrears, and hence I urgently request that the estimate of $10,000 for miscellaneous computation may receive favorable consideration.

DIVISION OF THE ALT-AZIMUTH INSTRUMENT.

In December, 1903, I decided upon the reorganization of the department of astronomical observations, as noted heretofore. It seemed that the three professors of mathematics stationed at the Observatory and the one assistant astronomer who had for several years been in charge of instruments were the natural heads of divisions. Mr. G. A. Hill, assistant astronomer, was at the time not only in charge of both the 5-inch steel alt-azimuth instrument and the prime vertical instrument, but was the sole observer on these instruments. He had completed nearly eleven years' observations of the nineteen that form the period of the revolution of the moon's node, and it seemed that this important series of observations, rarely if ever so continuously carried on by one person, should receive his undivided attention. I therefore subdivided his division, and placed the charge of the alt-azimuth instrument in the hands of Professor of Mathematics F. B. Littell.

From July 1 to December 1, 1903, Mr. Hill continued his vertical circle observations of stars of a list selected from those recommended by the Paris Conference of 1896 for publication in the nautical almanacs of the United States, Great Britain, France, and Germany, and published in the Astronomical Papers of the American Ephemeris and Nautical Almanac, Volume VIII, Part II, Newcomb's Suggested List of Fundamental Stars. I would add that Mr. Hill was loath to give up the charge of the alt-azimuth instrument, in which he had taken so much pride and which he had most energetically and efficiently handled for nearly six years for the best interest of the Observatory.

The work laid out for the instrument under the new management was to take up the observation of all the stars of Newcomb's Suggested List of Fundamental Stars, culminating here at zenith distances less than 75°.

As always in the case of a change of observers on a telescope, a study of the instrument had to take place. This work was carried on as expeditiously as possible, and soon active operations began, although the observations made since the reorganization have not been sufficiently reduced to determine the quality of the results. That the hard and intelligent work of Professor Littell with this instrument will bear fruit well worthy of the high character maintained by this Observatory's records can not be doubted.

DIVISION OF THE PRIME VERTICAL INSTRUMENT.

In the division of the prime vertical instrument, Mr. Hill has continued his series of observations for the purpose of obtaining the variation of latitude and corrections to the constants of aberration and nutation. He has completed nearly eleven years of the nineteen that form the period of the revolution of the moon's node.

Mr. Hill has finished the list of 390 stars which he has been observing on the prime vertical. Of these, 26 are contained in the Suggested List of Fundamental Stars, prepared in the Nautical Almanac Office, 9 are contained in the list being observed at the International Latitude Stations under the direction of the German geodetic service for the purpose of obtaining the variation of latitude, and 15 are contained in the lists used by Professor Doolittle, of the University of Pennsylvania, Philadelphia, in his latitude determinations. These recent observations will afford excellent material for improving the present knowledge of the star places and their proper motions.

THE PHOTOHELIOGRAPH.

Mr. G. H. Peters, photographer, in charge of the photoheliograph, has continued to photograph the surface of the sun each clear day of the year, to obtain a record of the spots which appear on its disk. The continuous record made by him of several years' duration not only affords a study of the solar surface upon which scientists have devoted much thought, but since such changes as are observed there are connected very intimately with the changes which take place in the magnetism of the earth, which in turn has a direct influence upon the compasses which guide our ships safely from port to port, the importance of this photographic work to the Navy itself is apparent. Unfortunately, owing to the close proximity of an electric-car line the work of the magnetic observatory that was connected with this station for many years was discontinued, but this has not lessened the necessity for continuing the important work of solar photography.

LIBRARY.

The library has continued in charge of the efficient librarian, William D. Horigan.

The value of this library as a standard for reference on scientific subjects is recognized not only by other departments of the Government, but by institutions of learning situated in Washington and elsewhere in the United States.

Soon radical changes will have to be made in its quarters to meet growing necessities, and to provide suitable accommodations for some of the most valuable publications belonging to the Government which are among its contents.

DEPARTMENT OF THE NAUTICAL ALMANAC.

The efficient work of the Nautical Almanac department has been maintained, and its force has been able to keep the current work up to date. About one-half of the American Ephemeris for 1908, and the same amount of the American Nautical Almanac for 1908 is in type, thus insuring their issue on January 1, 1905, the earliest date authorized by law.

Attention is called to the report of the Director of the Nautical Almanac recommending legislation governing the issue of a sufficient number of publications to supply the needs of the Navy Department, which is approved.

DEPARTMENT OF NAUTICAL INSTRUMENTS.

As shown in the report of its head, the work of this department has greatly increased and is increasing. As there was no naval officer available for assignment as the head of this department up to August 10, 1903, from the time of the Spanish war, the duties of this department were carried on in connection with those of the department of chronometers and time service. The work, therefore, mainly fell upon a force of one computer from the department of astronomical observation and a clerk detailed from the Superintendent's office to assist in the preparation of specifications, estimates, vouchers, bills of lading, reports, etc., incidental to the purchase, inspection, care, and issue of about $100,000 worth of the most delicate nautical instruments.

When Commander Robinson, in the early part of the year, was ordered to duty at the Naval Observatory he was assigned to the vacant position of head of this department; and Mr. E. A. Boeger, who had been taken from the computing division to carry on the work of the department, having in the meantime been appointed a clerk in the Superintendent's office to fill a vacancy, was continued as the sole civil employee in the department, which duty he has very energetically and satisfactorily performed. Mr. Boeger has become by experience an expert in testing nautical instruments, and it is desirable to retain his services in this department.

To carry on this important work I have provided in the annual estimates for an assistant in this department at a salary of $1,600 per annum, and respectfully urge that the position and salary may be provided for. It should be understood that duties in this department include not only the care and inspection of valuable instruments, but also all the labor usually performed by a staff of clerks at navy-yards in the purchase and inspection of the same and their issue to the fleet. A comparison of our force with that of any station which handles a like amount of material will show how inadequate is the force here, and when the character of the supplies is taken into consideration the proportions show markedly in favor of an increase for this station.

About 250 sextants alone, which have been inspected at the Observatory for the Navy during the past year, have required the continuous services of one person for about seventy-five days, and this amount of time, lengthened out by the various incidental calls on the department, has acted to lock up money which contractors have a right to expect thirty days after the delivery of supplies.

Recently the Treasury Department has made rulings regarding the payment for transportation of supplies which have added materially to the clerical work incidental to their issue to the fleet, and the Department must expect delays in executing shipment orders, or furnish the means of complying with them.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

Particular attention is called to the report of the head of the department of chronometers and time service. The importance of this department of the Naval Observatory can not be overestimated. This Observatory, like its prototype, the Royal Observatory of England, was founded for the purpose of establishing the position of ships at sea, and hence the inspection, purchase, and rating of chronometers, by means of which the longitude is obtained, have always been essential features of the work of both observatories. While the longitude may be obtained approximately without the appliances furnished by this department, yet navigation has become so dependent upon the use of chronometers that it would be a suicidal policy not to fit out ships with those which may be called standard in every respect.

The demands of our increased fleet have added quite as much proportionately to the work of this department as to that of any other department in the Navy. Not only has the number of chronometers been greatly increased, but the means of determining their accuracy here and the determination of their errors in service have so developed as fully to double the demand for personal attention. Repeatedly reports are received here relating to chronometers on board of the different ships of the Navy, and of special investigations that are being carried on in actual service, but under the supervision of this office, that require to be studied and carefully recorded to form a complete history of each chronometer in the Navy. For instance, as the Bureau has been informed, the question of what is the best material to be used in the construction of the spiral hairsprings of chronometers is a very important one; whether to use steel in their manufacture, as has been done for a long series of years, or to take up palladium or some alloy that is claimed to be an improved combination of metals, must be decided very soon. The tests applied to chronometers at this Observatory show that palladium is less susceptible to the variations of temperature, which, as our ships go to all parts of the world, is an important factor in their care; but whether the material will retain its spring as long as steel is yet to be determined.

American chronometer makers look to this department for scientific experiments in this and kindred subjects to guide them in their manufacture, and a conclusion can be reached only after many years of investigation; hence the care that must be taken to keep the records complete and to follow up the experiments accurately and persistently for many years. The force allowed to carry on this work is entirely inadequate. The test to which our chronometers, amounting to $40,000 or $50,000 worth, are subjected for a period of six months each year is a most absorbing occupation. The head of the department, who has many other matters of importance to attend to besides chronometers, is provided with the services of only one assistant. One man can not, as a rule, owing to the demands of the astronomical department, be kept on this duty longer than six months. He therefore hardly becomes familiar with his duties before he is withdrawn.

When it is considered that so delicate are the chronometers supplied the Navy that the Government sends an experienced officer to carry a few of them, valued say at $2,000 or $3,000, from point to point when necessary, at an annual expense for travel running up into many hundreds of dollars, it does not seem consistent to have the $40,000 or $50,000 worth of these instruments liable to be left in the hands of an inexperienced assistant, as the present system necessitates.

I have provided in the annual estimates for the salary of one assistant for this department at $1,600, which is the very least force that can properly do the work. If approved, the person selected for this position should be a graduate from some horological institution, who could make slight repairs to watches and clocks, as well as carry on the necessary computations relating to chronometers. When it is considered that the traveling expenses alone of officers who must carry these delicate and expensive chronometers from point to point will run up into hundreds of dollars, it does not seem extravagant to recommend the services of one assistant at the moderate salary of $1,600 to care for them at the Observatory, especially when it is remembered that such allowance will restore to his regular duties the computer now detailed to the position at the expense of the astronomical work.

I can not too strongly express my appreciation of the great amount and excellent character of work that has been done by Lieut. Commander E. E. Hayden, as his report shows, and I have felt guilty of neglect of duty in being obliged to furnish him with so small a force for meeting this important part of the demands of the fleet. This duty alone, which calls for the continuous work of four or five persons in institutions engaged in similar work to that carried on in this department, has, unlike them, another branch, which calls for a large share of the chief's attention. This is the time service of the United States, which is practically controlled by the Observatory, and which calls for incessant care.

The adoption of standard time with, all its manifold advantages, is the outgrowth of efforts put forth and developed by naval officers on duty at the Naval Observatory. When the great possibilities of this system became apparent, the railroad companies of the country, appreciating its necessity to themselves, took up the matter and, working in harmony with this Observatory, produced the general plan which has gradually been followed by the leading countries of the globe, and which all interested parties agree should be made universal.

The scheme for sending a greeting and announcement on the exact instant of the birth of the New Year to all parts of our country, as referred to in my last annual report, was so successful that it was repeated at the beginning of 1904, when it was extended to reach as far as England, Australia, Alaska, and Argentina, thus covering nearly three-fourths of the civilized world. Indeed, but for the demands brought upon the great eastern telegraph systems by the disturbances in China, it is believed that these signals would have extended around the world, and such a result seems more than possible for the beginning of 1905. This scheme, proposed by Lieutenant-Commander Hayden, has been received, as his report shows, with marked interest both at home and abroad. It all tends toward the general appreciation and adoption of a universal time system. As this country, more than any other, has helped to make international in character the adoption of Greenwich as the initial meridian of this system, so it would seem that our people, as the recognized leaders in the establishment of standard time, should endeavor to make it universal. The effort to do so will be maintained and the prospect of consummation is very good.

I take advantage of this opportunity to express my appreciation of the hearty voluntary cooperation of the various telegraph and cable companies in working so energetically and successfully with this Observatory in transmitting these special time signals over their lines, notably the great Western Union and Postal Telegraph companies and their connections. Perhaps with the development of wireless telegraphy it is not too much to expect that the day will come when not only every land station but every ship at sea will receive the daily noon signal from our standard clock, in which event practically all of the uncertainties of longitude determinations at sea will vanish. When that day comes (and it seems now to be entirely practicable) this clock may be heard in every land and on every ocean of the globe, and be available daily both for standard time and navigation everywhere.

On the recommendation of the Superintendent, with the favorable indorsement of Rear-Admiral W. C. Wise, commander in chief of the U. S. Training Squadron, and others, the Department, on March 24, 1904, established at Fort Monroe, Va., an office for the delivery of standard time from this Observatory to the fleet, which is often assembled in the waters of Hampton Roads, as well as to the large army station located there. With the cordial cooperation of the commanding officer of Fort Monroe, which met with the approval of the Army and Navy General Board and the Secretaries of the two Departments, a portion of a building on the Government wharf connected with the station was set apart for an office, and Lieut. Houston Eldredge, U. S. Navy (retired), was, by direction of the Navy Department, assigned to its charge.

I have already set forth in a report to the Bureau the desirability of thus giving direct from Washington the means for rating chronometers to the large number of naval vessels which in peace times frequently congregate there, and which as a station in war times they are likely to use as a base from which to operate against the enemy. But I wish to call attention to the valuable assistance which the Western Union Telegraph Company has given the service in establishing this office by running its lines without expense to the Government from its main office at the Fort Monroe army post—a considerable distance—to this office, and therein locating a sounder for the noon time signals sent out from this Observatory.

I forego forecasting the benefits which must accrue to the Army and Navy by the establishment of this office, but I am sure that Lieutenant Eldredge will so arrange its operations as to receive commendation from both services, as well as from the large mercantile fleet which will use the plant. With the removal of the old Hygeia Hotel the time-ball formerly established there was discontinued, and it is hoped soon to reestablish it at this new time-signal station, for the benefit of the Navy and commerce, to both of which it is essential.

DEPARTMENT OF MAGNETISM.

The Government has an important magnetic station near Washington connected with the United States Coast and Geodetic Survey, and it is the desire of myself as the Superintendent of the Naval Observatory to make such exchanges of records as will best subserve the interests of the General Government; but from outside of the United States, in the broad field covered by the ships of the American Navy and elsewhere, by exchange of data, we are accumulating records which will be valuable for a study of the magnetism of the entire earth. Not only are our large ships equipped with magnetic instruments for securing observations of terrestrial magnetism in localities which they visit, but recently, by authority of the Department, the valuable magnetic instruments that could no longer be used here were transferred to Tutuila, Samoa, for use in connection with the astronomical observatory which is in process of construction there. The magnetic station at Tutuila will cover a field from which there is as yet a dearth of information bearing on the subject, and will thus supply data of great practical and scientific importance. These changes have lessened the importance of the magnetic department, which by the regulations is a part of this Observatory, and to which in former years two naval officers were generally detailed for duty; but as it is essential to assimilate the records which come in from our own country with those received from abroad, I have detailed Mr. Peters, the photographer, to its charge temporarily.

In this connection I desire to call attention to the desirability of having the compass office, now located in the Navy Department building, associated with and made a part of this Observatory. The fact that all other navigational instruments, except compasses, issued to the vessels of the Navy come from this Observatory would logically point to the conclusion that this one instrument should also come from the same source, even if there were no other reasons for it. But as a direct connection has been shown to exist between sun-spot phenomena and terrestrial magnetism, which governs both the theoretical study and practical manipulation of compasses, it seems appropriate that the theory and practical knowledge relating to these important navigational instruments should go hand in hand. I would therefore recommend that the compass office be removed to and become the department of magnetism in the Naval Observatory. Other recommendations in this report covering the purchase of the Industrial Home School property, if approved, would make this scheme feasible as far as quarters are concerned, or in any event temporary accommodations could be arranged to meet the necessities of the combination without materially affecting the other work of the Observatory, and at the same time make available for other use the quarters now occupied by the compass office in the overcrowded Department building. Many other advantages would follow from such consolidation, such as abundance of space for out-of-door observations, the presence of a skilled instrument maker to make slight repairs, the consolidation of shipments to vessels, and the association of experts working along similar lines.

SUMMARY OF WORK.

Instruments—	Observations.
26-inch and 12-inch equatorials	1,377
9-inch and 6-inch transit circles	11,754
Alt-azimuth	1,495
Prime vertical	314
South transit (time service)	137
Photoheliograph	210
Total	15,287

	Number.
Chronometers, clocks, and watches inspected and rated	880
Nautical instruments inspected	4,245
Visitors admitted by permit	1,087

BRANCH OBSERVATORY AT TUTUILA, SAMOA.

The establishment of a branch astronomical observatory at Tutuila, as outlined in my last annual report, has continued to receive my attention during the year. Early in the fiscal year the commandant at Tutuila, Commander Underwood, ordered a board to recommend a site suitable for an astronomical observatory and magnetic house. The board, after careful consideration of the subject, recommended the purchase of land on Blunts Point, on the west side of the entrance to the harbor, as giving practically a north and south horizon free from obstructions. The approximate area recommended to be purchased is between 8 and 9 acres.

On further consideration of the matter by a board ordered by me to draw up detailed plans, the Bureau approved the scheme and the Department authorized the purchase of the land and the construction of the observatory.

Mr. C. W. Frederick, assistant on equatorial (who, with Asst. Astronomer G. A. Hill as senior member of the board and Asst. Astronomer J. C. Hammond as the other member, drew up complete plans for the transit circle house, the dwelling for the observers, including a clock room in which the temperature can be controlled, and partial plans for the magnetic house), was on my recommendation ordered to proceed to Samoa and report to the commandant of the naval station at Tutuila, to take charge of the observatory. Mr. Gustave Harrison, who for several years has acted as janitor of the great equatorial building and as general assistant in the care of the 26-inch equatorial, and who is a practical photographer of considerable experience, was at the same time appointed care taker of the observatory, as well as to act as assistant in magnetic and other work which is to be undertaken there.

Preparations are being made here to carry out the instructions of the Department.

MACHINE SHOP.

The machine shop established on the premises last year with old material from navy-yards, as mentioned in my last annual report, has already demonstrated its value.

Mr. W. W. Dinwiddie, assistant in spectroscopic work, has done, with little or no aid, some work on eclipse apparatus and made small repairs to other instruments of the Observatory. He has also completely overhauled the old Clark mounting of the 26-inch equatorial, which is being set up for carrying the tube of the old 9.6-inch equatorial, all of which material had been discarded. Two Dallmeyer cameras, each of 40-inch focus and 6-inch aperture, will also be carried by this mounting, and the 9.6-inch equatorial be used as a guiding telescope for photographing asteroids. This arrangement will permit an expansion of the asteroid work and allow the 26-inch equatorial to be used entirely for micrometric purposes.

Mr. Dinwiddie spent a large portion of his annual leave in visiting some of the important observatories of the country, spending a week at the Yerkes Observatory, bringing back to the Naval Observatory much useful data which have been utilized to the advantage of its plant.

I have also to mention that Mr. G. H. Peters, the photographer of the Observatory, likewise gave up practically all of his annual leave in the zealous search after information from other observatories which would benefit our work.

GROUNDS AND ROADS.

There still remains to be acquired to complete the plot of land lying within a radius of 1,000 feet of the Observatory's clock room, as contemplated by the joint resolution of Congress approved August 1, 1894, the tract belonging to Mr. Philip Young and the tract belonging to the Normanstone estate; also the property belonging to the District of Columbia, containing 6.764 acres, occupied by the Industrial Home School.

The question of title to the first two pieces of property remains in the District courts, to which it was referred on appeal from the decision of a board which condemned the land for Government use.

Referring to the Industrial Home School tract, the Department has stated in its letter to the District Commissioners of April 10, 1902, that "an agreement as to the equitable reimbursement of the Board (of Charities) for buildings situated within the Observatory Circle may be reached, which would enable the District Commissioners and the Department to unite in presenting to the consideration of Congress a measure that will fully protect the interests of the Observatory and the Industrial Home."

With a view to reaching such an agreement the Department appointed the Superintendent of the Naval Observatory, and the District Commissioners appointed Mr. George S. Wilson, secretary of the Board of Charities, to consider the matter. With Mr. Wilson I have endeavored to act as would a board of appraisers if condemnation proceedings should be instituted against this property, as recommended in the Superintendent's annual report of June 30, 1902, and which action it is not practicable to take without legislation.

The Department having agreed with the Commissioners as to the price of the land in question, viz, $74,404, which is at the rate of $11,000 per acre for the 6.764 acres of the Industrial Home School lands within the circle, as stated in the letter to which reference was made, it only remained for us to reach a conclusion as to the price of the buildings.

It is clear that any board of appraisers which might be established if condemnation proceedings were inaugurated through the courts would, as is usual in such cases, allow the District authorities not only for the value of the buildings located on the land which the Government proposes to take, but would award damages for such buildings as might be destroyed or otherwise rendered valueless by the transaction. Having reached an agreement as to the equitable reimbursement to the Board of Charities for the buildings, I submitted a report to the Department, and Mr. Wilson one of like purport to the Commissioners, embodying our conclusions. The arrangement submitted seemed the more desirable, owing to the fact that I saw and presented a scheme by which the Government could utilize, for a time at least, the buildings against which damages would fall.

The Department in considering my report ordered a board, composed of Rear-Admiral C. M. Chester, U. S. Navy, Civil Engineer R. E. Peary, U. S. Navy, and Lieut. Commander W. L. Burdick, U. S. Navy, to examine and report upon the same. The board states in its report that:

> We are of the opinion that the buildings, viz: the main building, the west building, and what is known as the schoolroom, which are all connected and form one large structure, can be made adaptable for the requirements of the Navy Department or some of the subordinate bureaus or offices; that the shops, boiler house, coal and spring houses and barn could be utilized as accessories to such offices. The cottage might be utilized for quarters for officers stationed here or could be turned into additional offices. The greenhouses would be of little practical value for Governmental purposes, but should necessarily be considered in the question of compen-

sation, as under any condemnation proceedings that might be instituted, if the parties at interest should be forced to that method of procedure, damages would unquestionably be allowed to at least the amount given. * * *

The only equitable settlement of the matter we believe to lie in the plan outlined in the report of the Superintendent of the Naval Observatory, dated December 9, 1903, for the Government to purchase all the buildings pertaining to the Industrial Home School, except the new schoolhouse which is isolated from the other buildings, and to secure, in addition to the purchase as contemplated in the joint resolution of Congress, approved August 1, 1894, a lease of such land outside the circle as may be necessary for the proper utilization of the buildings located thereon. This land will eventually be used for streets and is therefore not saleable by the District. This plan would enable the Government to make use of the two buildings located on such land, viz: the west building and the cottage; also a small portion of what is called the main building (shown on the plan appended, marked "B"), for a sufficient length of time (probably fifteen or twenty years at least) to partially compensate for their cost.

We therefore recommend that the Government acquire the property covered by the joint resolution of Congress approved August 1, 1894, on the basis of $110,000 for the buildings and $74,404 for the land, a total of $184,404; and to secure a lease at a nominal rental for such additional land outside the circle as may be necessary.

This report is referred to herein, as the Department's action on it was to direct as follows, on April 23, 1904:

In view of the advanced period of the Congressional session, it is believed that no action can be advantageously taken at this time upon the recommendation made by the Board in the within report. The matter will, however, be taken up and considered at the proper time in connection with such recommendations as may be made in the annual reports for this year or otherwise by the Bureau.

Congress having then decided by its joint resolution of August 1, 1894, that the Observatory grounds should consist of a plot bounded by a circle of 1,000 feet radius, the Department having come to an agreement with the District authorities as to the value of the land belonging to them within this boundary, and having ordered a board to consider "as to the equitable reimbursement of the Board (of Charities) for the buildings situated in the Observatory Circle," and the Board having recommended that the Government acquire the property covered by the Congressional resolution of August 1, 1894, and that it secure a lease of such additional land outside the circle as may be necessary, I respectfully urge that action be taken in time to present the matter to the next session of Congress. A definite scheme for carrying to execution the will of Congress, as expressed by its resolution referred to above, follows herewith.

Mr. George S. Wilson, representing the Commissioners of the District of Columbia, and myself, representing the Navy Department, acting under the instructions of our respective Departments, have agreed to submit the following plan in accordance with those instructions, viz:

The Navy Department (*a*) to acquire by purchase legal title from the Commissioners of the District of Columbia to the plot of ground that is situated within the Naval Observatory Circle, amounting to 6.764 acres, more or less, being parts of lands generally known as the Industrial Home School property, for the sum of $74,404. (*b*) To secure a lease from the District Commissioners at a nominal rental until such time as the land or the most of it may be required for street purposes, that other portion of the said Home School property described as follows: "Begin on the Observatory Circle where it intersects the north boundary of the Industrial Home School grounds; thence south 79 degrees 28 minutes west along said boundary a distance of 285 feet; thence south 275 feet; thence east about 160 feet to said Observatory Circle; thence northeasterly along said Observatory Circle to place of beginning;" about 1.40 acres. (*c*) To acquire by purchase title to all buildings on the aforesaid pieces of property at a cost of $110,000; a total of $184,404.

A plan marked "A" is herewith appended showing the status of land lying within the Observatory Circle and also giving the boundaries of the section which should be leased from the District Government to carry out the recommendation of the board which was ordered by the Department to consider the subject.

In the estimates of appropriations required for the service of the Naval Observatory for the fiscal year ending June 30, 1905, there was submitted an item for the building of two houses as observers' quarters. The necessity for the construction of these buildings has been noted in the annual reports of the superintendent for several preceding years and the necessity has not lessened. But as the question of the Government's acquirement of the property belonging to the District of Columbia, known as the Industrial Home School, has reached such a state as to warrant a hope that by the speedy transfer of the buildings on that property to this station the demand for quarters may be at least partially met, the estimates for the coming year will not contain this item.

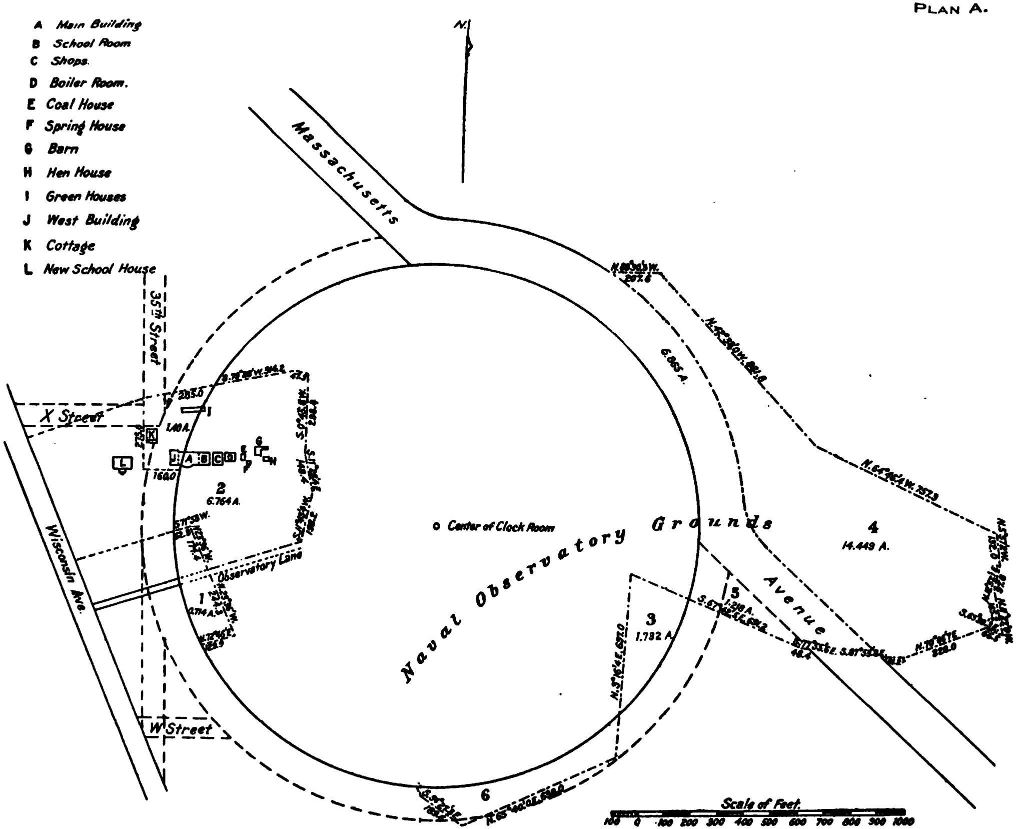
One of the acts of the Board of Visitors for 1901 was to report that "there is urgently needed residences for those who are regularly engaged in late night observations." For efficient work in observing the heavenly bodies those engaged in it must be near at hand or they will lose a great many of the comparatively few favorable moments available in this region for astronomical investigations. Particularly at this Observatory the distance of our instruments from habitations where the staff must live—in Georgetown or elsewhere—makes it exceedingly trying for the observers to go to their duty at all times of the night, and when the indications are unfavorable and they naturally go to their homes they must rely on irresponsible persons to awaken them when a change for the better occurs, with the chances in favor of their not getting to their stations. The result is that many observing nights are lost to the Observatory.

Suitable quarters are provided on the grounds for only two of the observers. Four others are temporarily provided with sleeping quarters in an old building which has been fitted up for them as best it could be done, but which affords them a less degree of comfort than would ordinarily be found in barracks for troops. The remainder are obliged either to sleep in their offices or off the grounds. This acts as a hardship on the members of the staff and results in less efficient service than should be rendered at an institution of this character.

If the scheme for the purchase of the Industrial Home School property is carried through, the buildings which it is proposed to buy and which in any event must be paid for will for the time being at least relieve the demand for new quarters for the major part of the staff.

The comparatively small amount of extra compensation asked for to reimburse the District of Columbia for their buildings lying outside the Observatory Circle will thus in more ways than one lessen the necessity for increased appropriations which the natural growth of this as well as all other Departments of the Government must entail.

As was predicted in the Superintendent's annual report for 1902, the appropriation of $5,000 allowed for the fiscal year ending June 30, PLAN A.



STATUS OF LANDS LYING WITHIN THE OBSERVATORY CIRCLE, JULY 1, 1904.

1. Philip Young, 0.714 acre, appraised $4,665.28. Condemnation proceedings under way. 2. Industrial Home School, 6.764 acres, negotiations progressing. 3. A. W. Fleming, "Normanstone," 1.732 acres, appraised $15,089.18. Condemnation proceedings under way. 4, 5, 6. Government property outside of the Observatory circle.

1903, and which was contained in the appropriation bill for the following fiscal year, has been scarcely sufficient for the care of the grounds, and but very little could be done in the way of grading.

A large portion of this property, which must eventually become one of the most conspicuous park reservations of the District of Columbia, is still as undeveloped as when it was a forest. A new portion, known as the Dumbarton estate, which was acquired by the Government in 1902, is still in the crude condition in which it was received. The rapid progress made during the year in grading Massachusetts avenue, now nearing completion, demands some treatment for this contiguous piece of ground at an early date. During the year, finding that the new grade of the avenue circling the Observatory property had created a dam for the surface waters, I requested that a board of medical experts should examine and report upon the sanitary conditions of the reservation. The Department ordered such a board, composed of Medical Director John W. Ross, U. S. Navy, Medical Inspector W. R. Du Bose, U. S. Navy, and Asst. Surg. Joseph A. Murphy, U. S. Navy. The following quotation is made from its report:

> Two pockets, parts of former ravines, one about 300 feet to the east and the other about 400 feet to the north from the Superintendent's quarters have been formed by the work of grading Massachusetts avenue and are objectionable from a sanitary standpoint, being without drainage and forming basins for the collection of surface water and refuse which would be favorable to the development of malarial and other fevers.
>
> In addition there is a depression at east entrance to Observatory grounds, formed by the grading of the same avenue, which it is desirable should be filled level with the grade to insure efficient surface drainage on that portion of the grounds.

The board also reported that—

> at the western limit of the Observatory grounds is located the property of the Industrial Home School, and here the board found a most objectionable, unsightly, malodorous, and insanitary condition, a veritable nuisance, menacing the health of the whole locality.

Continuing, the board recommends:

> 1. That the pockets and depressions in the Observatory grounds mentioned in this report be filled to grade.
> 2. That steps be taken to abate the nuisance connected with the sewage disposal of the Industrial Home School.

In order to provide the remedies recommended concerning the Government's property, the Department requested of Congress a special deficiency appropriation of $5,000, which was provided for in the act approved February 18, 1904.

With this allowance there has been removed from the slope on the eastern side of the Observatory property, to fill one of the sections mentioned in this report, covering about 4 acres of ground, an amount of earth equivalent to 30,000 cubic yards. This, at an average cost for such filling of 30 cents per cubic yard, would have cost alone by contract about $9,000.

A road about 550 feet in length, leading from Massachusetts avenue to the buildings within the circle, has been constructed and macadamized, and about 500 feet of old road have been resurfaced. To protect these roads, about 1,250 linear feet of guttering have been laid. Also about 100 square yards of concrete sidewalks have been laid. At contract price all this work would have cost over $10,000.

This piece of work is highly creditable to the foreman, Mr. W. M. Gorman, and when the whole filling is covered by a suitable lawn, it will add materially to the appearance of this part of the grounds, which has now become the main entrance to the Observatory reservation.

There still remain two pockets noted by the board to be filled and graded, and an additional appropriation will be required before all the recommendations can be carried out.

Regarding the Industrial Home School property, while the conditions have been bettered by the placing of a pumping plant to carry the sewage of the school into the sewer on the Tenleytown road, the remedy is only partial and can never be satisfactory while the present control is maintained. Knowing that the Government must eventually take this property, as contemplated in the law providing for the present location of the Observatory, the District Commissioners do not take much interest and will not expend much money in keeping it in proper condition.

The lane leading to the Observatory from the Tenleytown road is not a public highway, and while it runs adjacent to two pieces of property belonging to private parties the General Government alone must keep it in repair. Like Massachusetts avenue on the east, it is above the grade of the ground on either side of it, but unlike that avenue, by means of a culvert it passes over a stream of continually running water which rises in the Industrial Home School property, and which, during stormy weather, swollen by the surface waters of an extensive watershed can not be controlled. The result is that the roadbed is frequently submerged or washed away and requires constant repairs.

As a natural sequence to the filling of the depression, there had to be taken into consideration, in connection with the section at the east entrance of the Observatory grounds, the appropriate appearance of the grounds when the place should become one of the beautiful parks of Washington. This required not only the filling of the depression level with the grade of Massachusetts avenue, but the grading of the hill inside the circle from top to bottom. This accounts for the large amount of earth which it was necessary to handle. Further than this, as the main entrance to the grounds was now on grade a considerable portion of the appropriation had to be used for soil, grass seed, etc., to make the appearance conform to other parts of the grounds.

TOTAL SOLAR ECLIPSE OF 1905.

In my last annual report reference was made to the total solar eclipse which is to take place in August, 1905. I respectfully renew my recommendation that the Government should take part in this important event, and call attention to that report and to the reasons therein stated.

The estimates for the Naval Observatory for the past fiscal year contained an item for $6,000 for fitting out an expedition to observe this eclipse, and as Congress failed to make the necessary appropriation, probably owing to the fact that the eclipse would not occur during the fiscal year for which estimates of appropriations were being considered, I recommend that the same amount be again asked for, and that the appropriation be made available at the earliest possible moment after the opening of the coming session of Congress. Past experience shows that the longer the preparation the better the results, and undue delays in preparation are fatal. As the small amount of money asked for contemplates the use of one or more naval vessels and the employment of a considerable part of the force they carry to make the observations, it is necessary that the expedition should leave this country at least two months before the eclipse is to occur, August 30, 1905.

A continued study of the subject shows that Spanish astronomers are counting much on the support of interested Governments to make the occasion one of great importance to science. The Madrid Astronomical Observatory has published a map showing the region covered by the sun's total eclipse, and much consideration is being given to the selection of stations. The Spanish Peninsula seems to offer marked advantages for eclipse work, as there are practically three sections which give special meteorological contrasts: First, the eastern section, where the weather conditions are dominated by the influences of the Mediterranean Sea; second, the middle section, a plateau of considerable extent, the altitude of which produces conditions not found on the seacoast; and, finally, the western or mountainous region which breaks up to a large extent the storms passing over the Atlantic Ocean and neutralizes their effect in the other two zones.

It is thought, then, that by selecting one station among the high hills bordering on the Mediterranean to work with some ship as a base, say at Valencia, and another station in the uplands with headquarters on board of a vessel on the northern coast of Spain, the problem of chances would be in favor of excellent results.

Attention is called to the fact that the selection by the Naval Observatory party of two stations widely separated, at Fort de Kock and Solok, in Sumatra, at the time of the last solar eclipse expedition in 1901, brought to our party the only satisfactory weather conditions.

Heretofore it has been the practice to send quite a number of observers from the Observatory, which with our present depleted force is not permissible. The small appropriation asked for for the next expedition contemplates the utilization of a purely naval force, whose military training well equips them for this kind of work, and who, being guided by a few experts from this Observatory, are all sufficient for a large and well-equipped party. The details of the plan outlined above, carried out under naval auspices will, I believe, procure results worthy of the high stand this Observatory has always taken in such expeditions, and will redound to the continued credit of the Navy's service to mankind as a promoter of the arts of peace.

The political possibilities of such an expedition as proposed sent by the United States to the coast of Spain within the next year will, in my opinion, more than compensate for the outlay, even should no satisfactory observations be made of the sun's eclipse, but the chances are so greatly in favor of good weather at one of the two localities selected as to practically assure to astronomy and science in general data of great value.

APPROPRIATIONS.

It should be understood that with the present meager appropriations allowed for carrying on the work the great weakness of the Observatory lies in the inability to keep up to date the reduction of the observations. It is estimated that one observer can keep five computers employed for the period during which observations are taken. Here the object has been to make the best possible disposition of the force at my disposal by having some of the computers act as observers, so as to obtain a maximum amount of observations during the clear nights and then to have both observers and computers devote all their attention during bad weather to the reduction of the observations. This arrangement shows the inappropriateness of the designation computer, given by law, for at times the same class of people do both observing and computing work.

I have therefore to recommend that the title of computer be changed to that of assistant, and that the photographer, who is an important assistant in astronomical work, the assistant on the equatorial, and the assistant in spectroscopic work, be also styled assistant. This will harmonize with the titles of employees in the Nautical Almanac department of the Observatory, and best describe the duties performed. In view of the necessities of the case as explained above, and the desirability of having for the Observatory such an organization as is commensurate with its requirements and consistent with its plan of work, I respectfully submit the following, requesting that it may be considered in connection with the next annual estimates:

The permanent force outside of the naval officers assigned to duty at the Observatory to consist of the following:

	Salary.
In the department of astronomical observations:	
1 astronomer	$2,400
1 assistant astronomer	2,000
2 assistant astronomers, at $1,800	3,600
1 assistant astronomer	1,600
4 assistants, at $1,400	5,600
4 assistants, at $1,200	4,800
For miscellaneous computations	10,000
In the department of nautical instruments (including the general storekeeper's duties):	
1 assistant	1,600
1 stenographer	900
In the department of chronometers and time service:	
1 assistant	1,600

As showing the inadequacy of the meager salaries paid at the present time, I quote from the report to the Secretary of the Navy of the Board of Visitors in 1899, which was composed of Senator Wm. E. Chandler, Representative Alston G. Dayton, Prof. Edward C. Pickering, Prof. Geo. C. Comstock, and Prof. Geo. E. Hale, giving a proposed list of observers and salaries for the same, and I have placed in conjunction with this list the corresponding members of the Observatory's staff, with their salaries as they exist at present.

This report reads:

> If astronomers are appointed to the Naval Observatory from civil life to succeed retiring professors of mathematics the salaries provided should be sufficient, as recommended by you in that report for 1897, "to make up for the refusal to them of the privilege of retirement and also to secure men of high scientific attainments adequate to the demands of one of the most capable observatories in the world." To secure the services of the ablest astronomers the salaries provided should be slightly larger than those paid in the higher class of university observatories, and account should be taken of the fact that university vacations are much longer than leaves of absence from the public service. The board of visitors recommends the following as a schedule of salaries which could be expected to attract astronomers of the class desired:

Proposed staff.		*Present staff.*	
1 first astronomer	$4,000	1 professor of mathematics	$3,000
1 second astronomer	3,600	1 professor of mathematics	2,700
1 third astronomer	3,200	1 professor of mathematics	2,700
1 fourth astronomer	2,800	1 assistant astronomer	2,000
1 first assistant astronomer	2,400	1 assistant astronomer	1,800
1 second assistant astronomer	2,200	1 assistant astronomer	1,800
1 third assistant astronomer	2,000	1 assistant on equatorial	1,000
		1 assistant in spectroscopic work	1,000

It should be borne in mind that this report contemplated the elimination of all routine naval work, for which another and expensive establishment would be required, and therefore the professors of mathematics would be relieved of much labor which now falls upon them. In order that the Government may be able to withdraw all line officers from duty at the Observatory in times of public danger the present number of professors of mathematics should be maintained.

It seems that the fourth astronomer of the present staff should have the compensation which would put him on a par with what is known on the staff, as suggested by the Board of Visitors, as the first assistant astronomer. Moreover, since the present occupant of that position is a civilian of fifteen years' service in the Observatory, and is the head of a division in the department of astronomical observations, I recommend that the title of astronomer be established by law, at an annual salary of $2,400.

In this connection I desire to call attention to the fact that within the last two years two professors of mathematics have been detached from the Observatory to meet the demand for instructors at the Naval Academy, with the general understanding that vacancies among the officers of the Navy on shore made necessary by the large increase in the service should be filled by civilians. The vacancies thus created have not been filled.

In the schedule of officers and salaries submitted I have simply provided for the replacement of two professors of mathematics, who acted as astronomers, by one astronomer and by one assistant astronomer, leaving the remaining numbers of the permanent staff of the astronomical department as they exist to-day, but with new designations and a slight increase in their salaries.

The force in the department of astronomical observations not shown in the table above given consists of 1 photographer at $1,200 per annum whose services are extensively required in other departments of the Observatory, 5 computers at $1,200 per annum, and 4 miscellaneous computers at an average of $1,000 (paid out of appropriation miscellaneous computations, $4,000); 9 computers in all.

The growing importance of photography in astronomical observations gives to the photographer at this institution an entirely distinctive signification. His duties are of a scientific character and do not comport with the work commonly designated as photographic. I have therefore, in the annual estimates, recommended a change of his title to that of assistant in the department of astronomical observations. Mr. Peters has by his marked energy and zeal in the work of different departments of the Observatory more than earned the small increase of $200 which it is proposed to add to his salary. In connection with Mr. Hammond and Mr. Dinwiddie he has greatly increased the number of observations of asteroids which have been given to the astronomical world. The new guiding telescope which Mr. Dinwiddie is making out of the old and discarded material found here, as previously mentioned, will give him the means for a still further increase in the output and make his work still more closely connected with that of preparing the Nautical Almanac for publication.

The photographer is also the expert upon which the Department must rely for a knowledge regarding the proper photographic outfits to be furnished to our naval vessels, both cruising and surveying, and for the inspection of the same when they come to the Observatory for purchase and when prepared for issue. His direct connection with and importance to the active work of the Navy is thus clearly established and I trust will receive recognition by the Bureau and the Department.

To show the inadequacy of the present force, I beg to make a comparison also used in the report of the Board of Visitors referred to above, giving the approximate number of persons at the Naval and Harvard observatories:

Naval Observatory:	Number.	Harvard Observatory:	Number.
Professors of mathematics	3	Astronomers	6
Assistant astronomers	3	Assistant astronomers	13
Photographer	1		
Assistant on equatorial	1		
Assistant in spectroscopic work	1		
Computers (including miscellaneous computers)	9	Computers	18
Total	18	Total	37

As so many comparisons have been made between the Naval Observatory and the Royal Observatory at Greenwich in the past with reference to the work done, it seems only fair to state the number of the force engaged at Greenwich and also that the Royal Observatory has none of the work of supplying the fleet with navigational instruments other than chronometers.

The report of the astronomer royal for the year ending May 10, 1904, just received, shows that the astronomical staff at Greenwich consists of the following:

Astronomer royal	1
Chief assistants	2
Assistants	6
Established computer (higher grade)	1
Established computers (one vacancy)	10
Supernumerary computers	29
Total	49

I will not compare the results obtained from the two observatories, but I can claim, as does the astronomer royal, that "the record of the work of this Observatory for the past year is the best testimony to the spirit and zeal of the staff to whom great credit is due for the very satisfactory output of the work."

As stated, not only is our force in general drawn upon for incidental work pertaining strictly to the fleet, but one computer is necessarily attached to the department of chronometers and time service, and another, until recently, has been employed in the department of nautical instruments to take the places of naval officers, 4 or 5 in number, who were formerly detailed to this duty. It is probable that another computer must soon be detailed to the department of nautical instruments to keep up with the growing demands on its force.

As has been repeatedly reported, the scant force now attached to the Observatory can not keep up with its requirements. The computations have not only fallen in arrears, but to such an extent as to discourage the management and dishearten the staff. Several of its members have had offers of better positions and have only been kept here by the hope that their services would be recognized by the

Department by an increase of the appropriations for carrying on its work, and thereby the betterment of their condition. As showing that their efficient and zealous services have been recognized by the astronomical public at large, I can not forbear to quote from a letter to the Superintendent from the eminent astronomer, Dr. S. C. Chandler, of Cambridge, Mass., under date of March 4, 1904. It is as follows:

> This series of intercomparisons of the Saturnian system is remarkable for extent and completeness, as I have no doubt it will prove to be for quality of its results when tested by utilization in perfecting the theory of the satellites. I can not forbear congratulating your Observatory on the evidence which these and previous articles are continuously furnishing in such abundance, to the enrichment of current astronomy, of the value and importance of its renewed, successful and incessant activities.

At least the astronomical department should be relieved of the demand made upon its personnel by the necessities of equipping our large and increased fleet, and its size be restored to what it was before a number of naval officers were withdrawn from the Observatory and its work greatly augmented.

Very respectfully, your obedient servant,

C. M. Chester,
Rear-Admiral, U. S. Navy,
Superintendent of the Naval Observatory.

The Chief of the Bureau of Equipment,
Navy Department.

DIVISION OF EQUATORIAL INSTRUMENTS.

Sir: I have the honor to submit the following report of the division of equatorial instruments for the year ending June 30, 1904:

Asst. Astronomer T. I. King was in charge of the 12-inch equatorial from July 1 to November 15, 1903, at which date I was placed in charge. On December 1, 1903, the division of equatorial instruments including both the 26-inch and the 12-inch was established.

The distribution of the work of this division has been as follows: Professor Skinner, double stars; Mr. Hammond, occultations, comets, the brighter asteroids, and Jupiter's satellites; Mr. Dinwiddie, double stars, comets, the fainter asteroids, the satellite of Neptune, and the satellites of Saturn. With one exception Mr. Hammond has made all the observations with the 12-inch equatorial since November 15, 1903; the other observers have used the 26-inch equatorial.

Messrs. Hammond and Dinwiddie have endeavored to observe as large a number of asteroids as possible in the time not occupied by the observation of the satellites of the major planets. During the year covered by this report observations have been made of 99 different asteroids, of which 49 were observed by Mr. Hammond and 1 by Mr. Rice with the 12-inch equatorial, 44 by Mr. Dinwiddie and 5 by Mr. Frederick with the 26-inch equatorial.

On entering actively upon the asteroid work it occurred to Mr. Dinwiddie to use a Dallmeyer portrait lens of 6 inches aperture and 38 inches focal length which had been procured by the Observatory many years ago for eclipse work. An exposure with this camera of seventy-five minutes is sufficient to obtain a trail permitting the detection of any small planet which may be present on the plate. Mr. Peters has cared for this photographic work and has taken nearly all the photographs. Whenever necessary he has determined the places of asteroids by the measurement of the plate with the Stackpole measuring engine.

Two asteroids, which have not been identified with any previously observed, have been discovered by Mr. Peters. The first one, which was photographed December 11, 1903, has received the preliminary designation by the Recheninstitut of Berlin of (1903 NF), and the second one, which was photographed May 11, 1904, the designation of (1904 OF).

Professor Skinner has devoted practically his whole time to work in connection with the preparation of the catalogue of the Astronomische Gesellschaft zone −13° 50′ to −18° 10′, which work is referred to in detail in the report on the division of meridian instruments.

STATE OF THE INSTRUMENTS.

The 26-inch equatorial.—This instrument is in excellent working condition. The electrical illumination of the instrument and dome, designed and installed by Mr. Dinwiddie, continues to give complete satisfaction. Mr. Frederick has recently devised and installed a satisfactory bright field illumination by reflecting light to the inner surface of the objective by means of a prism within the telescope tube just outside of the cone of rays.

The 12-inch equatorial.—The mounting of this instrument is defective in several particulars. The chief difficulty is with the driving clock, which is so weak and ineffective that observations which demand the use of clockwork are made with great difficulty.

The constants of the instruments.—The constants of the two equatorials have been frequently determined for the 26-inch by Mr. Frederick, for the 12-inch by Mr. Hammond, and show that the instruments are quite steady.

Table of constants.

26-INCH EQUATORIAL.

Date.	Temperature.	ξ	η
	° F.	″	″
1903, October 13	60	−72	+114
1904, February 3	24	−61	+113
1904, May 7	65	−72	+115

12-INCH EQUATORIAL.

1903, December 6	30	+63	+29
1904, January 27	21	+82	+28
1904, April 4	40	+68	+27

OBSERVATIONS WITH THE 26 INCH EQUATORIAL.

Asteroids:

(42)	Isis	4	(350)	Ornamenta	3	
(46)	Hestia	3	(362)	Havnia	5	
(47)	Aglaja	3	(371)	Bohemia	3	
(49)	Pales	1	(374)	Burgundia	4	
(65)	Cybele	2	(379)	Huenna	5	
(84)	Klio	1	(381)	Myrrha	3	
(90)	Antiope	1	(382)	Dodona	3	
(108)	Hecuba	1	(386)	Siegena	5	
(153)	Hilda	1	(388)	Charybdis	5	
(154)	Bertha	4	(393)	Lampetia	5	
(156)	Xanthippe	3	(403)	Cyane	5	
(161)	Athor	3	(409)	Aspasia	5	
(163)	Erigone	8	(417)	Suevia	3	
(199)	Byblis	3	(420)	Bertholda	4	
(207)	Hedda	5	(423)	Diotima	2	
(225)	Henrietta	3	(426)	(1897 DH)	2	
(241)	Germania	2	(449)	Hamburga	4	
(271)	Penthesilea	4	(454)	Mathesis	4	
(301)	Bavaria	2	(455)	Bruchsalia	4	
(317)	Roxane	5	(478)	Tergeste	4	
(332)	Siri	5	(490)	(1902 JP)	2	
(333)	Badenia	7	(492)	(1902 JR)	2	
(334)	Chicago	3		(1903 NF)	5	
(339)	Dorothea	4		(1904 OF)	6	
(343)	Ostara	3			—	174

Satellites of Saturn:		
Tethys-Mimas	3	
Tethys-Enceladus	37	
Dione-Tethys	33	
Rhea-Tethys	47	
Titan-Tethys	40	
Hyperion-Tethys	6	
Japetus-Tethys	18	
Rhea-Dione	30	
Titan-Rhea	44	
Hyperion-Titan	18	
Japetus-Titan	48	
Rhea (fixed star)	13	
	—	337
Satellites of Uranus:		
Titania	11	
Oberon-Titania	9	
Oberon	2	
	—	22
Satellite of Neptune		8
Comet 1889 V (Brooks)		35
Comet 1904 *a* (Brooks)		2
Comparison stars		3
Double stars		165
Photographs of asteroid fields		96
Variable stars		4
Spot on Saturn		2
Occultation of star by the Moon		1
Total		849

OBSERVATIONS WITH THE 12-INCH EQUATORIAL.

Asteroids:

(2) Pallas	2	(79) Eurynome	3	
(5) Astraea	5	(80) Sappho	6	
(7) Iris	5	(81) Terpsichore	3	
(8) Flora	5	(89) Julia	5	
(10) Hygiea	6	(105) Artemis	4	
(11) Parthenope	5	(110) Lydia	4	
(14) Irene	5	(113) Amalthea	5	
(15) Eunomia	9	(114) Kassandra	4	
(18) Melpomene	4	(119) Althaea	5	
(19) Fortuna	5	(139) Juewa	4	
(21) Lutetia	5	(182) Elsa	5	
(22) Kalliope	5	(192) Nausikaa	5	
(23) Thalia	6	(196) Philomela	5	
(26) Proserpina	2	(198) Ampella	7	
(27) Euterpe	5	(202) Chryseis	4	
(28) Bellona	5	(270) Anahita	10	
(30) Urania	5	(306) Unitas	5	
(37) Fides	7	(313) Chaldaea	5	
(40) Harmonia	3	(324) Bamberga	8	
(51) Nemausa	5	(345) Tercidina	5	
(53) Kalypso	7	(349) Dembowska	6	
(56) Melete	5	(387) Aquitania	4	
(57) Mnemosyne	5	(405) Thia	1	
(63) Ausonia	5	(1904 NY)	14	
(64) Angelina	5		——	259
(67) Asia	6			

Satellites of Jupiter:

I-II	38	II-III	20	
I-III	24	II-IV	20	
I-IV	14	III-IV	15	
			——	131

Phenomena of Jupiter's satellites	45
Comet 1903 *a* (Borrelly)	15
Comet 1904 *a* (Brooks)	35
Miscellaneous stars	13
Diameter of Saturn	1
Diameter of Jupiter	4
Diameter of Venus	2
Occultations of stars by the Moon	23
Total	528

TABLES FOR DIFFERENTIAL REFRACTION.

The tables for differential refraction for the latitude of the Naval Observatory, referred to in the last annual report, have been completed by Mr. Frederick. One set of these tables is arranged for differences of right ascension and declination and the other set for position angle and distance. The tables will be published as an appendix to a volume of the publications of the Naval Observatory.

VISITORS.

As in former years, the 12-inch equatorial has been devoted one evening a week, and occasionally on other special evenings, to afford a view of telescopic objects to persons admitted to the Observatory by permit. Mr. Peters has been assigned to the duty of caring for these visitors.

The number of visitors received during the year has been 1,087 on 50 different evenings.

PERSONNEL.

A. N. Skinner, professor of mathematics, United States Navy, in charge of the 26-inch equatorial from July 1, 1903; temporarily in charge of the 12-inch equatorial November 15 to 30, 1903; in charge of division of equatorial instruments from December 1, 1903.

T. I. King, assistant astronomer, in charge of 12-inch equatorial July 1 to November 15, 1903.

John C. Hammond, assistant astronomer, from December 1, 1903.

W. W. Dinwiddie, assistant in spectroscopic work.

C. W. Frederick, assistant on equatorial.

Gustave Harrison, laborer.

Very respectfully,

A. N. Skinner,
Professor of Mathematics, U. S. Navy, in Charge.

The Superintendent of the Naval Observatory.

DIVISION OF MERIDIAN INSTRUMENTS.

Sir: I have the honor to submit the following report on the work of the division of meridian instruments for the fiscal year ending June 30, 1904:

The observations made in this division up to September 4, 1903, are reduced and ready for publication, and those made since that date are in various stages of reduction.

THE 6-INCH TRANSIT CIRCLE.

This instrument was in active operation only for a portion of the year, during which time it was devoted to the determination of the right ascensions and declinations of the sun, moon, and planets, and a few miscellaneous stars. The miscellaneous stars observed were used as comparison stars in the observation of asteroids with the 12-inch equatorial.

All the observations made with this instrument were strictly differential, and a sufficient number of ephemeris stars were observed with each one of the objects, whose position was to be determined to obtain the clock corrections and the equator points.

The number of observations from July 1, 1903, to September 4, 1903, is as follows:

Ephemeris stars	487
Sun	30
Moon	24
Mercury	18
Venus	28
Mars	1
Jupiter	6
Saturn	14
Uranus	6
Miscellaneous stars	17
Total	631

Of these observations there were made by—

Professor Littell	175
Mr. Rice	217
Mr. Brown	239
Total	631

A very thorough discussion of the variation of the constants of this instrument with the temperature, extending over the period from September, 1902, to September, 1903, has been made by Professor Littell, and the results will appear in the Introduction to Volume IV, Part I, Publications of the United States Naval Observatory, Second Series, now in press. He finds that the collimation constant exhibited great stability, showing a variation of $+0^s.0007$ for each increase of 1° F.; that the azimuth was subject to an annual variation of $-0^s.011$ and to a daily variation of $+0^s.005$ for each increase of 1° F., and that it was impossible to connect the changes in level with the changes in temperature.

Since this instrument has been out of commission it has received a thorough cleaning, and the location and erection of a south mark has been commenced.

THE 9-INCH TRANSIT CIRCLE.

Observing with this instrument was commenced on September 3, 1903, after a number of changes, spoken of in my last annual report, had been completed.

This instrument has been devoted to the determination of the right ascensions and declinations of the sun, moon, planets, the stars of Newcomb's Suggested List of Fundamental Stars, and the stars of Gill's Catalogue of 2,798 Zodiacal Stars, with the addition of about 350 stars not in Gill's list.

In the observations of the zodiacal stars, and of the moon and the planets when observed in connection with those stars, one observer takes the transits and makes the micrometer bisections, while a second one sets the instrument, reads the microscopes, and keeps the record. In the other work the observer works alone, except on the sun and occasionally on the moon.

The reductions are so carried on that each observation will give the right ascension and declination of the object observed, the plan of observing ephemeris stars for clock corrections and equator points only having been discontinued.

The number of observations from September 3, 1903, to June 30, 1904, is as follows:

Zodiacal stars	5,590
Standard stars	4,670
Screen stars for personal equation	436
Astronomische Gesellschaft Zone zero stars	4
Astronomische Gesellschaft Zone zone star	1
Sun	141
Moon	106
Mercury	51
Venus	95
Jupiter	8
Uranus	6
Neptune	15
Total	11,123

Of these observations there were made by—

Professor Skinner	5
Professor Eichelberger and Mr. Rice	172
Professor Eichelberger and Mr. Yowell	5,992
Professor Eichelberger and Mr. Morgan	219
Professor Eichelberger	15
Professor Littell (three months)	1,212
Mr. Rice	1,294
Mr. Brown	1,458
Mr. Morgan (seven months)	756
Total	11,123

To observe a star of the second, third, or fourth magnitude with the 9-inch transit circle with the full aperture is exceedingly unsatisfactory, so that the instrument has been provided with two wire-gauze screens attached to the object-glass end of the telescope, so mounted that the observer at the eye end can easily and quickly screen or unscreen the object-glass, either or both screens being used. One screen reduces the brightness of a star two and a half magnitudes, and the other one five magnitudes. All the work of making and attaching the screen apparatus was done at the Observatory by Mr. Cleve. Beginning with September 3, 1903, all stars have been observed as between the sixth and ninth magnitudes. The screen has been found to be of advantage in night observations of the moon and also in observations of Jupiter.

Another improvement in the method of observing is the using of both a south and a north meridian mark. With the collimators and the marks two independent determinations of the collimation are obtained, and after a value of the collimation has been adopted from these two sets the two marks give two determinations of the azimuth.

The south collimator for the 9-inch transit circle was not provided with any means of readily adjusting its vertical thread, and as the position of the image of that thread as viewed in the transit circle was much affected by changes of temperature, the collimation was frequently determined when the distance of the image from the middle thread of the transit circle reticule was probably too great or too small for the best results. Mr. Cleve, the instrument maker, has remodeled the eye end of the collimator so that now the vertical thread can be easily and quickly adjusted to any desired position.

The circle microscopes were provided with new micrometer screws by Mr. George N. Saegmuller, in May, 1904, as the old ones had become much worn.

In order to protect the thermometer shelter from the direct rays of the sun during the early morning and late afternoon in summer, a shed of single louvre work has been built over it. This shed is open on the entire north side, and in order that the thermometer might the more quickly take up any change in the temperature of the outside air, the original shelter was changed to single louvre work, and its north side was hinged so that it could be open during work at night.

The series of measures with an axial collimator for the determination of the irregularities of the pivots of this instrument, referred to in my last annual report, indicates a slight irregularity. If the observations are reduced on the assumption that the pivots are perfect, the time of transit thus obtained must be corrected by a quantity varying between $+0^s.02$ and $-0^s.02$.

Several series of observations by the different observers to determine their personal equations depending on the magnitude of a star by the use of wire-gauze screens give the following results:

The amount by which the time of transit of a star is observed later, when its brightness is reduced two and a half magnitudes.

Observer.	Number of stars observed.	Difference in time of transit.
		s
Eichelberger	59	+0.025
Littell	52	+0.009
Rice	85	+0.009
Brown	105	+0.030
Morgan	91	+0.045

The following values of the horizontal flexure applicable to observed zenith distances have been determined by the use of horizontal collimators:

Date.	Observers.	Horizontal flexure.	Temperature.
1904		" "	° F.
Jan. 25	Eichelberger and Yowell	−1.09 ±0.02	34
Apr. 11	.....do	−1.13 ±0.03	56

THE CLOCKS.

The new clock, Riefler No. 70, with a nickel-steel pendulum and inclosed in a glass air-tight case, made by Riefler, of Munich, was received at the Observatory in July, 1903. It was set up by Mr. Hutterly, a local clock maker, in the clock vault, and was installed as the standard sidereal clock on September 1. For several weeks it worked satisfactorily, but since that time it has given some trouble. While the case was perfectly air-tight for at least six weeks, since November it has been impossible to maintain a constant pressure in it. A second difficulty has been that the electric winding apparatus would at times fail for a few seconds, then recover itself and work perfectly for days without any change whatever being made in the batteries. A third difficulty has been the occurrence of extra breaks on the chronograph at the time of winding of the clock.

The use of this clock was discontinued on May 19, and it has been returned to the maker, at his request, in order that he may correct the difficulties.

Another clock, Riefler No. 60, was set up in our clock vault in March for testing before shipment to its station at Guam. This clock is a duplicate of the former one except that it has a maintaining spring. Its case leaked from the first, but now, since its joints have been worked over by Mr. Cleve, it seems to be air-tight. This clock also produces occasionally extra breaks on the chronograph at the time of the winding of the clock, but it has never failed to wind since we have had it. It has been used as the standard sidereal clock since May 19.

The following rates are deduced from a preliminary reduction of the observations, in which the irregularities of the pivots and the effect of the screens used in observing are neglected and in which a preliminary set of relative personal equations of the observers is used:

Rates of Riefler No. 70.

Date.	Daily rate.
1903	*s*
Sept. 10.4	−0.04
11.6	.08
12.5	.06
13.8	.08
14.4	.07
15.6	.10
16.3	.11
19.5	.12
21.6	.14
22.5	.17
23.5	.05
24.5	.11
25.5	.08
26.3	.13
27.8	.11
28.5	.11
29.6	.08
30.5	−0.12
Oct. 1.5	

GENERAL REDUCTIONS.

The order of the Superintendent, dated November 27, 1903, states that—

> The committee on editing and printing shall consist of * * *, the head of the division of meridian instruments to be the secretary.
>
> The secretary to the committee shall be the custodian of all records in the archives of the department of astronomical observations, and shall have charge of the proof reading and the preparation of printer's copy of this department and of such reductions of observations and checking as can not be done in the division in which the observations are made.

Astronomische Gesellschaft Zone Catalogue —13° 50′ to —18° 10′.—The precessions and secular variations for 1900.0 for this catalogue are finished. The 1,431 stars in Bessel's Zones that are also in this catalogue have been reduced to 1900.0 for purposes of comparison, and a similar reduction of the stars in Lalande's Histoire Celeste, Argelander's Southern Zones, and Münchener Sternverzeichniss I and II is in progress. This work is being carried on under the direction of Professor Skinner, and much of it is being done by him personally.

Washington Zone Catalogue.—The work of revising the Washington Zone Observations of 1846–1849, as described in detail in my last annual report, has been pushed as much as the limited force of computors and the press of other work would allow. The comparison of the mural zones with the Cordoba General Catalogue has been completed, and from this comparison zone corrections for about half the zones have been deduced. These corrections have been applied to all the stars of the first 25 zones. The preliminary revision of the transit zones is about two-thirds completed and about one-fourth of the zones have been compared with the Cordoba General Catalogue.

The 1,000 unpublished observations made with the meridian circle in 1851–52 have been reduced to 1850.0 and the reduction of the 3,500 unpublished observations made with the same instrument in 1847–48 is well advanced. The reductions of these unpublished observations are being carried on under the direction of Professor Littell.

In the published results from the mural zones the right ascension of nearly 4,000 stars and the declination of over 4,000 stars have been changed. All changes in the published positions are made only after a personal inspection by Professor Eichelberger.

Printing.—Since the last report, Volume V, Publications of the United States Naval Observatory, Second Series: Meteorological Observations and Results, 1893–1902, has been published. Parts I and II, Volume IV, are in type, and the printer's copy of Part III is more than half ready. The plates for the illustrations of Appendix I, Volume IV, Reports on the Total Solar Eclipses of 1900 and 1901, are being made, and it is expected that the presswork will be begun this summer.

PERSONNEL.

The following members of the Observatory force have been attached to this division at some time during the year ending June 30, 1904, the first six principally as observers, the remainder as computers engaged in general reductions under the direction of the committee on editing and printing:

Prof. William S. Eichelberger.
Prof. Frank B. Littell, for five months.
Asst. Astronomer Herbert L. Rice.
Computer William M. Brown.
Computer Everett I. Yowell.
Computer Herbert R. Morgan, for seven months.
Computer John C. Hammond, for three months.
Computer Eleanor A. Lamson.
Computer Arthur B. Turner, for one week.
Miscellaneous Computer Etta M. Eaton.
Miscellaneous Computer Delonza T. Wilson, for one month.
Miscellaneous Computer Charles E. Yost, for ten weeks.
Miscellaneous Computer Charles N. Moore, for ten weeks.
Miscellaneous Computer Alice M. Gray, for seven months.
Miscellaneous Computer Ella A. Merritt, for six months.
Miscellaneous Computer Florence A. Graves, for six months.
Miscellaneous Computer Matt Frederickson, for three months.
Miscellaneous Computer Perez Fisch, for three months.
Miscellaneous Computer L. Adolph Richards, for three months.
Miscellaneous Computer Jesse Pawling, jr., for one month.

Only a small portion of Mr. Hammond's time was spent on general reductions, the larger portion being given to making asteroid observations on the 12-inch equatorial and reducing the same.

The large number of miscellaneous computers is due to the inability to secure eligibles for these positions during the early months of the fiscal year. The regular number is four.

In conclusion I desire most heartily to commend the willingness with which each and every duty assigned to members of this division is undertaken, and the painstaking faithfulness with which it is performed, and further, to call attention to the fact that the value of the service performed by the computers doing duty as observers is far in excess of the renumeration they receive.

Very respectfully,

W. S. EICHELBERGER,
Professor of Mathematics, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

DIVISION OF THE ALT-AZIMUTH INSTRUMENT.

SIR: The alt-azimuth instrument was in charge of Mr. Hill until December, 1903, when the division of the alt-azimuth instrument was established by the Superintendent with a view to enlarging the work of this instrument by assigning to it an observer unhampered by other observing duty. From July 1 to December 1, 1903, Mr. Hill secured 465 vertical-circle observations of stars of a list selected from those recommended by the Paris Conference.

After the establishment of the new division it was decided to take up the observations of all of the stars of Newcomb's Suggested List of Fundamental Stars culminating here at zenith distances less than 75°. The number of stars on the list is 1,186 above the pole and 136 below the pole. When the zenith distance is greater than 10°, a double observation is obtained, one a few minutes before and one a few minutes after meridian passage, the instrument being reversed in the interval. The observation is made by noting the time of the oblique transit of the star over the horizontal thread at the middle of the field. For stars of smaller zenith distances the instrument is clamped in the meridian and used as a meridian circle. By making the bisections at the side of the field the observer is able to secure a double observation with reversal. The number of vertical-circle observations secured from December 1, 1903, to June 30, 1904, is 1,030, making a total for the year for this instrument of 1,495.

The observations have not been sufficiently reduced to determine the quality of the resulting declinations nor the relative efficiency of the two methods of observation.

The two alidade levels and the striding level were tested during the winter, and as the striding level tube showed some superiority to the upper alidade level, it has been substituted for it.

The determination of the division errors of the circle is planned for the near future. The circle will also be shifted at intervals.

In order to maintain the verticality of the axis of the instrument it has been found necessary frequently to adjust the base screws by small amounts, and to facilitate this adjustment they have been provided with pointers and graduation by the instrument maker of the Observatory.

The necessity of a more suitable house for the alt-azimuth and of the erection of collimators has been noted in several previous reports, and I urge the desirability of early action on these matters.

Very respectfully,

FRANK B. LITTELL,
Professor of Mathematics, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

DIVISION OF THE PRIME VERTICAL INSTRUMENT.

SIR: For the year ending June 30, 1904, the following is respectfully submitted as the report upon the operations in my division:

The prime vertical transit instrument having been in constant use since the spring of 1893, it was decided at the beginning of the fiscal year to dismount it for general cleaning and repairs. Specifications outlining the conditions that demanded rectification were submitted to two astronomical instrument makers. The estimate of The Warner & Swasey Company, of Cleveland, Ohio, being the lower as well as the more satisfactory, was accepted.

An examination of the instrument after it had been taken down, as well as previous knowledge of its condition, indicated that the following repairs were required:

To refigure and repolish the pivots; to cut new scores in the reticule plate, and replace the system of transit threads by a more elaborate one; to remove the lacquer from the outside of the cube and the two tubes, and the dead black from the inside; then to repaint all parts, and reproduce a dead black on the inside of the cube and tubes; to clean the micrometer box, including the screw and the micrometer head, and the setting circles; to reface the two wyes; and to resurface the friction rollers upon which the instrument rests.

During the time the instrument was away for the above repairs, Mr. Cleve, assisted by Mr. Coulon, dismounted the reversing apparatus that is fastened to the pier beneath the floor of the observing room, and gave each part a thorough cleaning with gasoline. They also removed the paint from the upright supports that hold the instrument when it is being reversed, the level frame, the level crane, and its different parts. These were all repainted to correspond to the other portions of the instrument as repaired by the instrument makers.

Mr. Cleve has also remodeled the mercury basin to prevent, as much as possible, tremors reaching the thin film of mercury therein.

In the specifications sent to bidders special emphasis was laid upon the requirement that in figuring the pivots they must be polished and lapped to as near true cylinders as it is possible to make them. The Warner & Swasey Company, with the advantage of their fine machines, have shown great skill in reforming the pivots, and they have produced two as nearly true cylinders as modern mechanical methods can obtain.

The system of transit threads formerly in use consisted of two tallies of seven threads each, spaced on either side of the thread that approximately marks the middle of the field and with sufficient interval therefrom to permit the instrument to be revolved 180° after the star had passed the thread nearest to the middle thread and before it would reach the same thread on the opposite side of the field. The instrument can be reversed without haste, then reset to the proper zenith distance of the star, within a period as short as thirty seconds of time.

The equatorial interval of the threads was about three seconds. A star on the prime vertical, and relatively near the zenith, moves quite slowly. For example, *α* Lyræ formerly consumed eleven minutes in making a complete transit from the first thread to the last one on the reversed set. In the new reticule, devised by the observer, the space between threads has been so reduced that it takes the same star only five minutes to transit the same number of threads.

One of the possibilities in prime vertical transits made in accordance with the Struve method, i. e., in which the instrument is reversed at each vertical for the purpose of eliminating the error of collimation, is that the collimation may change in an interval as large as 11 minutes. To guard against that possibility the scores on the reticule plate have been placed with a width of only $\frac{1}{250}$ of an inch between each. The observer has long been convinced that the reticule should be so formed that transits direct and by reflection would be possible. Advantage was taken while the instrument was dismounted to have scores made for two additional tallies, of seven threads each, placed outside of those mentioned, and so spaced therefrom that sufficient time would be allowed after a star had transited one of these outer sets to repoint the telescope for an observation direct or by reflection over one of the inner sets. In other words, the method of procedure is to observe a star direct over one of the outer tallies, then repoint the telescope and observe over one of the inner sets by reflection, reverse the instrument and go through the same process. By that scheme the error of level of the instrument is eliminated from the transits, whatever may be its value, as is also the inequality of pivots, and the mean of the two resulting declinations observed direct and by reflection is free from any visual determination of the level by aid of a spirit vial. A complete check is had upon a change in the remaining instrumental error, the azimuth, from readings made on the azimuth mark through the long focus lens, both before and after the transit of the object across each of the two verticals.

The instrument was out of use from August 15 until November 12, 1903.

Observations of the list of 390 stars, for their declinations, mention of which was made in the last annual report, were completed in February, 1904. Five observations have been secured of each star, as this number is considered ample for the purpose of giving a good position. The majority of these stars have not been observed for the past forty years, except for the two or three observations secured in the zone observations made under the direction of the Astronomische Gesellschaft. In a few instances I have found evidence of proper motion.

The completion of observations of these faint stars has led to a study of the accordance of declinations of the two classes of stellar images, bright and faint, when observed in the prime vertical. The data that have been accumulated indicate very clearly that better and more accordant declinations and the periodic changes in these may be secured from fainter than from brighter stars. These two terms include, first, stars between the magnitudes 5 and 7.5 and, second, between the magnitudes 1 and 3.5.

Commencing in February last the observer has adopted the polygon method of observing with the instrument for the purpose of obtaining the variation of latitude and a correction to the constant of aberration, which method has been used with such marked success by zenith telescope observers. Four groups of four stars each have been selected. The average right ascension for each group has been made as nearly as possible six, fourteen, eighteen, and twenty-two hours, respectively. The average magnitude of the stars in each of the four groups is 6.8, 7.2, 7, and 7. It is not practicable to include more than four stars in a group, because it occupies so much more time to observe a star in the prime vertical than it does in the meridian either with a zenith telescope or with a meridian or vertical circle. It will take from seven to eight hours to secure transits of the stars in two groups when both are observed on the same night. The magnitude of α Lyræ and θ Aurigæ, which stars are included in two of the groups, will be reduced by the aid of a wire screen to conform to the other stars in their respective groups.

With the prime vertical transit instrument there have been secured during the year 314 observations. There have been made to date, from the commencement of observations at this Observatory, 1,095 observations of α Lyræ, and this closes the eleventh year of continuous observations with the instrument by the same observer.

The following is a statement of the condition of the reductions:

The transits are entered on the reduction sheets up to January 24, 1904. They are completely reduced, and finally checked up to the commencement of 1903. They are entered on the printer's copy up to January 1, 1902. During the year I have carried through the complete reduction of 667 transits. The checking of that work has, for the most part, been done by Miss Lamson. The annual precessions and the secular variations for the epoch 1900, for the 390 stars, have been computed by myself, and they are now ready to be checked.

An additional computation that is nearing completion is a determination of the latitude of the instrument, from observations extending over the past ten years, basing it upon the three standard systems of declination now at the service of astronomers, namely, that of the Fundamental Catalogue prepared in the United States Nautical Almanac Office, that of Prof. Lewis Boss as published in the Astronomical Journal No. 531, and that of Dr. A. Auwers, after applying the corrections to his star places as printed in the Astronomische Nachrichten Nr. 3927–9. The stars common to these three systems have been reduced to each mean year covered by the prime vertical observations.

With these data the difference between catalogue declination and observed declination has been taken for all individual observations. From about 30 of those differences a well-determined value of $\Delta\phi$ will be secured, which is to be applied to the latitude used in making the reductions. The above method will be followed so as to secure well-determined latitudes extending over the entire period of this series of observations, and each based upon the mean of 30 values of $\Delta\phi$. To each of those determinations and for each system will be applied the latitude variation that has been computed and published both by Dr. S. C. Chandler and Doctor Albrecht. The probable error of the latitude as obtained from these three systems will then be computed. So far as the observations are concerned the result of this discussion, based on a continuous series of ten years' observations, will be interesting in showing which of the three systems has the smallest probable error when all the star places used are referred to the same point in the heavens. The results of the discussion will be printed in one of the astronomical journals.

Observations were continued with the vertical circle until December 1, 1903, when, by order of the Superintendent, I was relieved from charge of the instrument. From July 1 until November 30, 1903, 465 vertical circle observations were secured.

The reductions are now eighteen months in arrears, not to mention the checking of the copy for the printer, extending over the past ten years. The copy has been made by myself, and it will have to be read by two persons before it goes to the printer. It contains over 3,000 observations. Moreover, the first ten years' work should be reduced for the purpose of determining the constant of aberration. In that discussion over 1,400 equations of condition will have to be computed.

I wish to express my appreciation of the assistance I have received from Miss Lamson, who has practically done all the checking on the work after I had made the first reductions. Her computations and checking have been both thorough and accurate.

Very respectfully,

Geo. A. Hill,
Assistant Astronomer, in Charge.

The Superintendent of the Naval Observatory.

THE PHOTOHELIOGRAPH.

Sir: I have the honor to report that during the fiscal year ending June 30, 1904, the sun has been photographed with the photoheliograph on two hundred and ten days, and solar spots and faculæ were observed on these plates on one hundred and ninety-two days. This is an increase over the preceding year of eight days on which the sun has been photographed, and of ninety-three days on which spots were observed.

An enormous group of spots, the largest since 1898, made its appearance on October 5, 1903. This was announced from here, and received much notice in the daily and scientific papers and the magazines. During the year several other large groups, though smaller than the one just mentioned, were observed but were not publicly announced. The definition and quality of these solar photographs, owing to the exact determination of the temperature variation of the focal plane, is very excellent.

As lenses of the type used for this sun work are also employed for large scale photographs of the inner corona on eclipse expeditions, it was decided to procure a new, larger, and improved lens, for which the contract has been let. The aperture is to be 7.5 inches and the focal length 65 feet. This length will give an average solar image of 7 inches diameter instead of 4¼ inches, which is the size given by the present lens. This lens is to be of triple construction, and corrected for both the visual and actinic wave-lengths of light. This correction will permit the use of either ordinary or orthochromatic photographic plates with equal advantage, since the new lens will bring all wave-lengths practically to one focal plane. In eclipse work this is of especial advantage, as the light from the chromosphere and prominences will come into exact focus.

Very respectfully,

Geo. H. Peters,
Photographer, in Charge.

The Superintendent of the Naval Observatory.

LIBRARY.

SIR: I have the honor to submit the following report on the library for the fiscal year ending June 30, 1904:

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1903	18,870	4,053	22,923
Accessions	406	80	486
Contents July 1, 1904	19,276	4,133	23,409

Of the accessions, 287 were received as exchanges and 199 were purchased.

The following publications were distributed:

Publications, Second Series, Volume V, containing Meteorological Observations and Results, 1893–1902.

Report of the Superintendent for 1903.

Since July 1, 1903, all the scientific pamphlets have been catalogued.

In regard to the small number of purchases reported during the last five years, it should be stated that the prices of higher class technical works are much higher than those of ordinary books. In the literature of mathematics and astronomy the Observatory library is the most complete and valuable in the country. It is especially rich in the serial publications of the older scientific bodies of Europe and in the scientific journals of the last century. But unfortunately there are gaps in some of the series. Most of the books required to fill these gaps are rare and difficult to obtain, and it is highly important to obtain them before they become rarer and more costly.

The library is used not only by the scientific bureaus of the Government and the institutions of learning in Washington, but its value is recognized and it is consulted by scientific workers from distant parts of the United States. About half of our present appropriation is expended in subscriptions to serial publications dealing in astronomy. And after desk books, upon which there is considerable wear and tear, are provided for the various departments, including the Nautical Almanac, there is but little left for the purchase of either old or new books or to provide the necessary fixtures for the library. Therefore, in order that the library may be kept up to its present standard, the amount of $1,000, the annual appropriation for the fiscal years 1887 to 1898, is considered essential for the future.

The shelving provided for the library when the Observatory removed to its present site accommodates but two-thirds of the present collection. The other third is partly stowed away on unstable shelves in the old record room, out of reach, and insufficiently lighted. The remainder is in the basement, surrounded by steam pipes, lumber, and packing materials. It seems that the time has come when some steps should be taken to provide modern fireproof shelving for the overflow. Whether this could best be accomplished by constructing another gallery and extending the alcoves in the rotunda or by erecting stacks there or elsewhere is a question requiring careful consideration.

Very respectfully, WM. D. HORIGAN,
Librarian.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

DEPARTMENT OF THE NAUTICAL ALMANAC.

SIR: I have the honor to submit the following report of the operations of the Nautical Almanac Office for the fiscal year ending June 30, 1904:

PRINTING.

The following publications were received during the year from the Government Printing Office:

The American Ephemeris and Nautical Almanac for 1907, first edition, 1,010 copies.

The American Nautical Almanac for 1907, first edition, 510 copies.

The Pacific Coaster's Nautical Almanac for 1904, first edition, 1,786 copies.

The American Ephemeris and Nautical Almanac for 1904, second edition, 729 copies.

The American Nautical Almanac for 1903, second edition, 152 copies.

The American Nautical Almanac for 1904, second edition, 2,340 copies.

DISTRIBUTION OF PUBLICATIONS.

During the fiscal year ending June 30, 1904, the sale and distribution of publications were as follows:

Title.	Sold.	Public service and exchanges.	Total.
American Ephemeris	793	1,078	1,871
American Nautical Almanac	2,711	269	2,980
Atlantic and Pacific Coaster's Nautical Almanac	1,625	42	1,667
Astronomical Papers	14	64	78

The proceeds of sales, amounting to $1,847.13, have been deposited with the Treasurer of the United States to the credit of public printing.

THE AMERICAN EPHEMERIS.

I have to report that the current work of this office is fully up to date, the American Ephemeris for 1908 and the American Nautical Almanac for 1908 being about one-half in type, thus insuring their issue on January 1, 1905, the earliest date authorized by law.

The omission from the British Nautical Almanac of the Lunar Distances has caused the cancellation of an agreement entered into some years since whereby the work of preparing these computations was divided between the two offices. The publication of the Lunar Distances is, however, continued in the American Ephemeris.

MISCELLANEOUS.

Recent legislation by Congress has reduced far below its needs the number of copies of the American Ephemeris authorized by law to be supplied to the Navy Department for sale and distribution. It has been necessary to supply the deficiency by requisition upon the funds of the Navy Department, although the law provides that the proceeds of the sale of these copies be deposited to the credit of the general printing fund. It is respectfully suggested that legislation be recommended providing for the printing of the full number of copies needed for sale and distribution.

Very respectfully,

WALTER S. HARSHMAN,
Professor of Mathematics, U. S. Navy,
Director Nautical Almanac.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

DEPARTMENT OF NAUTICAL INSTRUMENTS.

SIR: I have the honor to submit the following report of the department of nautical instruments for the fiscal year ending June 30, 1904:

The supply of nautical instruments to vessels in commission, or about to be commissioned, to navy-yards and shore stations, wireless telegraph stations, the naval militia, etc., has proceeded regularly and promptly, in accordance with the shipment orders received.

Invoices for all expenditures have been promptly prepared and forwarded, and since April 1, 1904, bills of lading have been prepared and issued with all shipments made by either freight or express.

Requisitions for instruments necessary to replenish stock have been prepared and the instruments purchased have been inspected, marked, and stored ready for issue.

In January a survey was held on a large number of instruments which had been returned to the Observatory from ships and stations during the year, the invoiced value of which exceeded $11,000.

The following facts, as bearing on the supply of nautical instruments to naval vessels, are deemed worthy of notice, viz:

(*a*) A board for the trial of prismatic binoculars convened at the Observatory by order of the Chief of the Bureau of Equipment on October 22, 1903, and after an examination and test of samples of glasses submitted by various American makers and agents of foreign makers reported that, all things considered, it was deemed most advisable to purchase for naval use the prismatic binoculars made by The Warner & Swasey Company, of Cleveland, Ohio. Since then this firm has devised amber shade-glasses to be fitted to the eyepieces of its binoculars which are found to have the valuable feature of deepening contrasts without in any way detracting from the definition. Twelve pairs of these glasses thus fitted were purchased for issue to naval vessels and 50 more have been ordered.

(*b*) The specifications for deck clocks have been revised and specifications prepared for boat clocks, all of which are of such a character as to insure naval vessels being supplied with the best marine clocks which the market affords and at a very reasonable cost.

(*c*) Steps have also been taken to insure the issue to ships of a better and more reliable class of thermometers than formerly. Of 325 air and 320 water thermometers purchased since October, 1903, only one of each failed to pass inspection.

(*d*) In January a new sextant testing machine was received from the makers, the Keuffel & Esser Company, of New York. This is a handsome, accurate, and finely finished instrument, by which the long and arduous labor of inspecting sextants has been lightened and greatly facilitated.

Your attention is most urgently invited to the pressing need of increased expert and clerical assistance in this department of the Observatory. The officer in charge has, to assist him, only the partial services of one clerk, class 2, Mr. E. A. Boeger. This gentleman has qualified himself as an expert in the inspection of instruments of precision and as such his services are invaluable, but the work of inspection is hampered and delayed by the multiplicity of his clerical duties which call for the preparation of the following papers, viz:

1. Requisitions for instruments and supplies of all kinds.
2. Inspection calls for all instruments and other supplies received.
3. Vouchers for payments of instruments, supplies, repairs, freight and express bills; together with the calculation and report of penalties incurred by contractors for late deliveries.
4. Invoices of all expenditures.
5. Bills of lading for all shipments by express or freight.
6. Reports of receipt of shipment orders, of shipments made and of shipments received.
7. Monthly reports of stock on hand.
8. Quarterly reports of receipts and expenditures, together with the accompanying abstracts of receipts and expenditures under both classes "A" and "B."
9. Quarterly reports of work done.
10. The posting of expenditure, receipt, and requisition books.
11. Together with the preparation of letters and indorsements, the frequent search of records for information desired by bureaus and individuals, the filing of certified bills, shipment orders, approved requisitions, notices of contracts awarded, and numerous other papers. He is, in fact, charged with all the clerical work, and must have the whole routine and business of the department at his fingers' ends.

A comparison of the table at the end of this report with those submitted in former reports will show the great increase of the work of this department over that of years preceding the large increase in the number of vessels in commission.

There are required immediately for the proper performance of the functions of this department in its rapidly increasing business:

First. The exclusive services of the present assistant.

Second. An additional clerk to assist in the inspection of instruments, preparation of papers, and keeping accounts.

Third. One stenographer and typewriter for the writing of letters, reports, indorsements, etc., and for the relief of both of the above from such clerical duties as may be possible, leaving them more time for the most important and engrossing work of inspection and test of nautical instruments.

The number of shipments made during the year was 338, amounting in value to $71,719.30.

The value of instruments received during the year was, by purchase, $58,727.40, and by return from navy-yards, etc., $38,605.66.

The number of instruments received and issued during the year is shown in the following table:

Receipts and issues of nautical instruments.

Name.	Purchased.	Issued.
Artificial horizons	20	24
Azimuth circles		1
Barometers, aneroid	88	85
Binoculars:		
Day	290	237
Night	370	296
Prismatic	59	50
Cameras, photographic		2
Chains, surveyor's		2
Chronometers:		
M. T. hack	2	26
M. T. standard	15	65
Clinometers	65	79
Clocks:		
Boat	175	69
Deck No. 1	260	76
Deck No. 2	143	93
Compasses, surveyor's		1
Dip circles		2
Dividers, navigator's	85	60
Drawing instruments (cases)	76	42
Heliographs	1	
Levels, surveyor's		1
Magnetometers		1
Octants	30	42
Parallel rulers:		
Sigsbee	60	9
24-inch	90	37
18-inch	105	56
15-inch	50	51
Photographic outfits		2
Plane tables		1
Protractors, three-arm	70	30
Psychrometers	81	33
Reading glasses, captain's	38	33
Sextants:		
High-grade	55	32
Squadron angle		26
Surveying	130	51
Splines and weights, sets	50	28
Spyglasses:		
High-power	45	78
Low-power	80	88
Medium-power	15	67
Officer-of-the-deck	225	195
Tapes, steel:		
100-foot	60	27
300-foot		3
Telescopes, large (on tripods)	2	5
Thermometers:		
Air	403	260
Maximum and minimum	2	41
Water	472	291
T-squares	50	40
Watches:		
Chronometer		2
Comparing	53	41
Stop	35	36
Torpedo-boat	3	9

Very respectfully,

J. M. Robinson,
Commander, U. S. Navy, in Charge.

The Superintendent of the Naval Observatory.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

SIR: I beg to submit the following report of the work of this department for the fiscal year ending June 30, 1904:

Mr. H. R. Morgan, computer, remained on duty in the department for the first half of the year and was relieved on January 1, 1904, by Mr. C. N. Moore, computer, who remained in the department for the remainder of the year, after May 1 as a miscellaneous computer. I take pleasure in saying that both of these gentlemen rendered very intelligent and valuable services as soon as they became familiar with the special work on hand, and were indispensable in carrying on the work of the department.

RECOMMENDATION OF INCREASE OF FORCE.

I beg to repeat my previous recommendations that a permanent expert computer, at $1,600, be allowed to this department, because much of the time of a new computer detailed for the position is occupied in acquiring familiarity with all of the details of his duty. It would be economical, also, to have another assistant, at $1,400, with sufficient special technical training to clean and adjust clocks, watches, and at least hack chronometers. The saving of expense for such repairs in a year would, it is believed, more than pay his salary and at the same time enable the work to be done quicker and without any of the clerical work that is now necessary on the part of this Observatory and the Bureaus of Equipment and Supplies and Accounts in making requisitions, obtaining bids, awarding contracts, and forwarding articles back and forth by express. No private firm doing such a large and important business in this line would hesitate a moment in employing such an expert, and the necessity is still more vital here, in view of the emergencies of naval work in both peace and war.

SAVING OF TIME WITH INCREASED EFFICIENCY.

Every effort has been made, in view of the short-handed condition of the Observatory force, to adopt every possible expedient by which to save time without loss of accuracy, and in two instances this has resulted so favorably that they seem worthy of mention, as follows:

Inasmuch as the new Riefler clock in the clock vault was found to give excellent results, as used by the division of meridian instruments, I recommended that a wire be run from it to the chronograph in this department, in order that it might be used in connection with the other clocks of this department. With your approval this was done, and since November this fine clock has been available for our use, without even the necessity of ever walking over to get its face reading. Moreover, the regular star observations of the division of meridian instruments have been worked out promptly by the computer on duty in this department, thus saving the time and labor involved in the use of our own transit instrument, which is now available for other work.

A second and minor instance, but still of considerable importance in the saving of time daily, is a quick method that has been adopted of recording on the chronograph the comparisons of the many chronometers and watches that are under trial. Hitherto it has been done quickly by pressing an electric key at any ten-second reading of each chronometer, with an arbitrary signal to indicate which 10 the signal indicated, but at present it is done much more quickly by pressing the key at any five-second interval, a dash half a second long indicating 5, 15, 25, etc., and one second long, 10, 20, 30, etc. Then, in reading the chrongraph sheet, read units and tenths, adding 5 to the reading of the short dashes, and record the proper figure as shown by the regular weekly face comparison. In obtaining and recording data for 100 chronometers this method saves fully fifteen or twenty minutes a day, and is perfectly reliable.

The new forms that were prepared and printed last year for use in keeping chronometer records and deducing results of daily comparisons, trials, and performance at sea have also resulted in the saving of time and increased accuracy of results.

CHRONOMETERS WITH NICKEL-STEEL COMPENSATION.

In view of the experimental and apparently successful use abroad of marine chronometers with balances of nickel steel, or invar, a composition of wonderfully small coefficient of expansion, this department recommended that some be tried in our service. With your approval and that of the Bureau two chronometers of this kind were purchased (Nardin No. 115 and No. 120), subjected to an exhaustive trial at this Observatory, and are now undergoing a sea trial of three months on board of the U. S. S. *Hartford*. By thus keeping abreast of the times and utilizing whatever seems to promise improvement, it is hoped to serve the best interests of the Navy and of American commerce, as well as of American chronometer makers, who will doubtless watch the trial with great interest and profit by its results.

CHRONOMETERS FROM THE LOUISIANA PURCHASE EXPOSITION.

For reasons similar to those stated above it was suggested, in reply to inquiries from the Bureau relative to the cost and performance of foreign chronometers as compared with those made in this country, that the exposition at St. Louis furnished a good opportunity to enable us to put through the next regular chronometer trial at this Observatory a few of the best foreign marine chronometers on exhibition there, with a view to comparing them with our own. Arrangements have accordingly been made to do so, with the inducement held out to the various makers that some of their instruments would be purchased if they passed the trial well. Such action bids fair to add to our naval chronometers a number of the very best instruments of foreign make, and the results of the trial of all the various chronometers under identical conditions at this Observatory can not fail to be of great interest and value.

PROPOSED TRIAL OF TORPEDO-BOAT WATCHES.

It having become necessary to purchase more torpedo-boat watches for use in the service, a type of watch not yet manufactured in this country, it seemed desirable to notify the principal American watchmakers, as well as firms of established reputation abroad, in order that they might be given an opportunity to compete if they so desired. Specifications were accordingly prepared, approved by the Bureau, and sent to leading American and foreign firms. It is regretted, however, that as yet no American firms have accepted the invitation to compete.

It is understood, of course, that the manufacture of a new type of watch involves a large initial expense, and that the present purchase, even in its entirety, would by no means justify such an undertaking; and yet it would seem as though some enterprising firm might find in possible future sales for the use of the Navy, yachts, carriages, automobiles, railroads, and other sources of demand for a large, clear, accurate $100 watch, such a market as would justify the necessary plant. The proposed trial will be similar in all respects to the regular annual trial of chronometers, and take place at the same time, beginning in January next and ending the following June. The prices offered by the specifications range from $150 to $75, according to the results of the trial.

TRIAL OF NEW DECK CLOCKS, WATCHES, AND HACK CHRONOMETERS.

Much of the time of the department has been occupied with the trial of ordinary deck clocks, comparing watches, and stop watches, purchased from time to time as required and tested according to the various specifications issued by the Bureau. The following tabular statement will serve to indicate the amount of work of this kind that has been done, especially when it is remembered that the instruments come each in different lots, not all of a kind together, and that the periods of trial vary from one to three months, according to the type of timepiece:

Tried during the year:

Deck clocks No. 1	194
Deck clocks No. 2	188
Boat clocks	109
Comparing watches	113
Stop watches	114
Hack chronometers	8

In addition to the above 6 torpedo-boat watches were tested under the old specifications, the trial lasting twelve weeks.

THE INSPECTION OF NAVIGATIONAL INSTRUMENTS.

As senior officer of the board of inspection it has been my duty to assist in the inspection of, and certify to the correctness of bills for, all the navigational instruments purchased, as well as of the many other articles that are required from time to time.

As regards the inspection of navigational instruments I take pleasure in expressing my appreciation of the invaluable assistance of Mr. E. A. Boeger, formerly a computer and now clerk class 2, whose long experience in such inspections has made his expert work and opinion of the greatest value, and who, by reason of my own absorption in my regular duties, has done practically all of the delicate expert work required by such inspection. In other inspections I have been materially assisted by Mr. G. H. Peters, photographer, Mr. William M. Gorman, captain of the watch, and other members of the Observatory force, according to the nature of the articles to be inspected.

In this inspection alone there is, in my opinion, ample work to justify the detail of a line officer whose entire time could be occupied by it, to his own advantage as well as to that of the Observatory and the entire service, inasmuch as the thorough inspection of navigational instruments before issue is a matter of actual necessity.

TRANSIT INSTRUMENT REPAIRED.

Advantage has been taken of the present system of using in this department the Riefler clock and observations of the division of meridian instruments to send the 5-inch south transit instrument, which has been in constant use for many years and has long needed a thorough overhauling, to The Warner & Swasey Company, of Cleveland, Ohio, for repairs. When returned it is expected that it will be equal in all respects to a new instrument, and I understand that it is your intention to have it utilized in connection with some special line of work not directly connected with the work of this department. This change will be of undoubted advantage to the Observatory as a whole, both by preventing what has long been practical duplication of a part of the work and by enabling every instrument to be used to the best possible advantage.

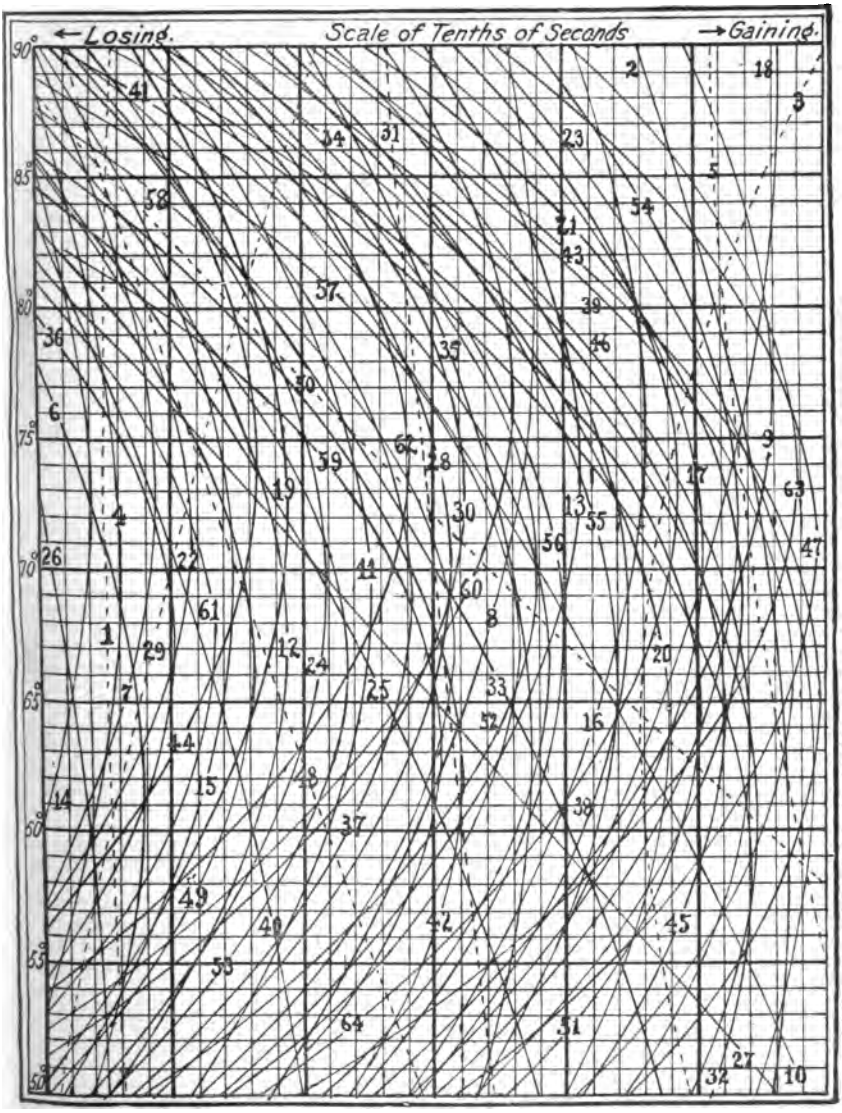
TRIAL OF A NEW TYPE OF SHIP'S CHRONOMETER CHEST.

The board appointed by your order of February 8, 1904, to design a new type of ship's chronometer box or chest by reason of a complaint referred to this Observatory by the Bureau, consisting of myself as senior member, Mr. H. C. Cleve, instrument maker, and Mr. W. W. Dinwiddie, assistant in spectroscopic work, submitted a plan involving certain modifications of the type of wooden chest now in use. Not entirely satisfied with this plan, however, I have made further efforts, with your approval and that of the Bureau, to design and construct two different types of chest, with a view to (1) a better stowage of the chronometers as regards liability to rapid changes of temperature, (2) a better material as regards fireproof or at least slow-burning construction, and (3) a utilization of the ordinary or of an improved type of transporting case, which is now stored away and of no use during a vessel's entire cruise.

As a result of these efforts, involving considerable correspondence and experiment, two new types of chest have been constructed and have been sent on board of the U. S. S. *Hartford* for a practical trial at sea this summer in comparison with the old wooden type of chest already on board.

In requesting such sea trial the object was to adhere to the well established principle that it is of the greatest importance to test at sea under actual conditions on board of naval vessels every new type of equipment intended for such use. The report of this trial will naturally be given great weight in any future recommendation on the subject, involving, as it may, a possible change of type of chronometer chest for the entire service.

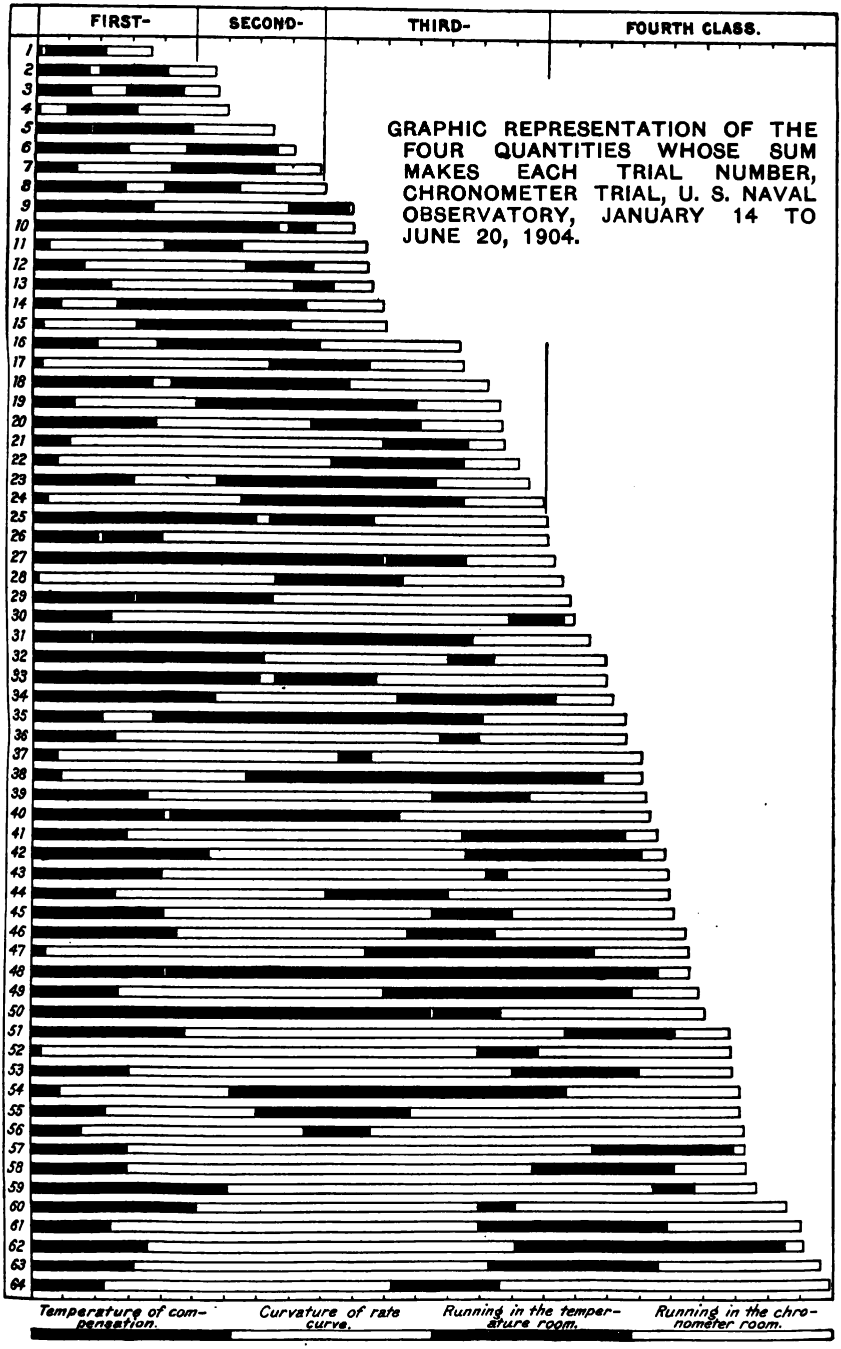
PLATE I.



TEMPERATURE RATE CURVES, CHRONOMETER TRIAL, U. S. NAVAL OBSERVATORY, JANUARY 14 TO JUNE 20, 1904.

The numbers are those of order of merit in the entire trial. The dotted curves indicate overcompensation.

UNIV. OF MICH.



GRAPHIC REPRESENTATION OF THE FOUR QUANTITIES WHOSE SUM MAKES EACH TRIAL NUMBER, CHRONOMETER TRIAL, U. S. NAVAL OBSERVATORY, JANUARY 14 TO JUNE 20, 1904.

UNIV. OF MICH.

REGULAR ANNUAL TRIAL OF CHRONOMETERS.

This trial began at noon, January 14, and ended at noon, June 20. It began with 42 new chronometers, subject to purchase after the trial, 60 old mean-time standards, 6 sidereal chronometers, 15 torpedo-boat watches, 6 chronometer watches, and 4 thermometric chronometers, a total of 112 chronometers and 21 watches, 133 in all. The temperature-room trial ended on April 8, and the chronometer-room trial on June 20. Some of the chronometers and watches were withdrawn for issue during the trial, most of these, however, late enough to allow of the calculation of an approximate trial number, but 81 chronometers and 17 watches completed the entire test.

The accompanying tabular statement of data gives the complete results for all those instruments for which trial numbers below 25 were obtained, and the results are gratifying both as to the number of new chronometers that passed and as to the good trial numbers obtained by the majority of old chronometers and watches.

With your approval and that of the Bureau, all of the old naval chronometers and watches that passed through this trial were surveyed and appraised with the new trial numbers as a basis of value, thus insuring that when issued they shall be invoiced at prices consistent with their present value for use in navigation. It is proposed to continue this plan hereafter, and thus do away with the old system of maintaining inconsistent book prices irrespective of actual changes in value.

Plate I shows graphically the rate curves of all the chronometers and watches that won a trial number below 25, and Plate II gives a graphic representation of the four quantities whose sum makes each trial number. These two plates are of especial interest in connection with similar plates published in my last two annual reports, and it is proposed to publish others in future reports, thus gradually completing what it is hoped will prove to be a useful graphic record of the trials, under the same conditions, of a large number of different makes and kinds of instruments.

THE TIME SERVICE.

The daily noon signals, now so useful and well known all over the country, have been continued regularly and with even greater accuracy than usual, the average error for the year being only fourteen-hundredths of a second, for the last six months thirteen-hundredths, and for the last three months nine-hundredths. This increased accuracy of the time service, while not materially important so far as the general public is concerned, which does not bother about a few hundredths of a second, indicates an improvement of real importance in connection with very delicate and accurate horological work, such as rating chronometers, telegraphic longitude determinations, etc., and it is of course the aim of this department to have the noon signals as nearly absolutely correct as possible. The least appreciable error of these signals, or of the fall of the time-balls dropped by them, enters directly into the latest determinations of the chronometer rates of ships on the eve of sailing, and such error accumulates daily as long as the voyage continues.

NEW YEAR'S EVE TELEGRAPHIC TIME SIGNALS.

The plan commenced on New Year's eve, December 31, 1902, of sending out a series of telegraphic time signals at midnight, 1, 2, and 3 a. m., seventy-fifth meridian time, to announce the exact instant of the beginning of the new year to each of the great standard time belts of the United States, was repeated again this year, and with even greater success than before. The system of signals was exactly the same as that used daily at noon, as explained by the text and diagram accompanying my annual report for the fiscal year ending June 30, 1902. The series of signals, it may be repeated, begins at five minutes before the hour, includes each second of the clock except the twenty-ninth, the last five of each of the first four minutes, and the last ten of the last minute, after which long break there is a single long contact, the beginning of which marks the exact hour.

In order to secure as wide a distribution of the signals as possible, both as a matter of sentiment and in the interests of the universal adoption of accurate standard time, various telegraph and cable companies were notified of the plan, and most of them entered into it with great interest. Indeed, but for pressure of business on the part of the Eastern Extension and Australasia Telegraph Company, the signals might have been transmitted around the world. As it was, however, they reached as far as England, Australia, Alaska, and Argentina, thus covering nearly three-quarters of the civilized world and traversing about 300,000 miles of wire. Widespread newspaper comment showed general public appreciation of the signals, as transmitted by the Western Union, Postal, and American Telephone and Telegraph companies, and the extent of their distribution is illustrated by the fact that the Western Union Telegraph Company alone sent them through 186,173 miles of land lines within the United States, which probably leads the world in its appreciation of the value of accurate time.

The many reports received serve to give a slight, although of course incomplete, idea of the success with which the plan was carried out, and it should be remembered that it was done entirely by voluntary cooperation on the part of all concerned, whose willing and effective assistance is very highly appreciated. The signals were accurately timed at several observatories. They reached the Royal Observatory at Greenwich, England, in $1^{s}.33$; Lick Observatory, California, in $0^{s}.05$; the National Observatory of Mexico in $0^{s}.19$; Sydney Observatory, Australia, in $3^{s}.5$; and Wellington Observatory, New Zealand, in $4^{s}.0$. They where heard at Dawson, Skagway, Juneau, and Sitka, Alaska; at Panama, Valparaiso, and Buenos Ayres; at Honolulu, Guam, and Manila; and they traversed the cables beneath the Atlantic and Pacific oceans to announce to distant continents the exact instant of the beginning of the New Year in the United States.

OTHER SPECIAL TIME SIGNALS.

It seems manifest that it is for the best interests of this Observatory to encourage the sending out of such special time signals, especially whenever it can be done without expense or even any appreciable inconvenience. The standard clock and telegraphic connections being in daily use are always ready, and the sending of a special time signal involves but little more trouble than the turning of an electric switch. At the same time, every such signal adds its share to the popular appreciation of the work of the Observatory and to the increased knowledge and interest in the subject, both within and without the limits of the United States.

For this reason it is recommended that advantage be taken of important meetings in this city, such as that of the Eighth International Geographic Congress, to meet in September next, and the International Railway Congress, in May, 1905, to offer to send out to the world, as far as the telegraphs and cables will carry them, a special series of time signals, in celebration, as it were, of the meeting, and to invite to this Observatory such of the members as care to be present to see them go out. The two congresses referred to have, moreover, much more than a mere sentimental interest in the subject, as the universal adoption of standard time is a matter of great importance to geographers and railroad men, perhaps above all others.

THE PRESENT STATUS OF THE USE OF STANDARD TIME.

In view of the part that this Observatory has taken in the adoption of standard time in the United States, from which it has spread to many other countries, and of the numerous inquiries that are made to us on the subject, I recommend that an effort be made to collect and publish as complete data as possible regarding the kind of time in actual use in the various countries of the world. With your approval and that of the Bureau much information of this kind has already been collected.

Very respectfully,

EDWARD EVERETT HAYDEN,
Lieutenant-Commander, U. S. Navy, in Charge.

The SUPERINTENDENT OF THE NAVAL OBSERVATORY.

O

ites N

mber

nged.)

2	90
3	Ap
.	Ap

7
1
6
9
3
0
7
7
1
9
7
3
0
4
7
4
4
9
7
7
3
21
1
09
1
34
0
74
3
9
21
71
61
10
0
29
6
74
3
14
74
4
79
1
0
0
30
7
79
9
0
27
1
74
17
20
3
46
51
0
0
24
11
73

lics.

tes Naval Observatory, Washington, 1

mber greater than 25.00 omitted.

nged.)		Chronometer-room trial, me			
2	90.08	74.38	69.21	76.07	
	60	38	37	45	
3).	Apr. 1 to Apr. 8.	Apr. 11 to Apr. 18.	Apr. 18 to Apr. 25.	Apr. 25 to May 2.	
7	+0.11	−0.29	−0.11	−0.37	
1	+0.39	−0.11	−0.27	−0.36	
6	−1.26	−0.36	−0.36	−0.70	
9	−2.99	−2.80	−2.87	−3.21	
3	−2.53	−2.03	−2.01	−1.99	
0	−2.01	−2.40	−2.49	−2.36	
7	−0.71	−1.17	−1.13	−1.47	
17	−0.01	−0.17	−0.03	−0.30	
11	+1.69	+0.96	+0.93	+0.93	
9	+1.43	−0.10	−0.29	−0.03	
97	−2.56	−3.04	−3.19	−3.40	
3	+2.34	+0.33	+0.23	+0.40	
0	−0.39	−1.17	−1.16	−1.37	
4	+0.09	+0.09	−0.07	−0.19	
7	−0.94	−1.63	−1.79	−2.14	
4	−0.76	−0.37	−0.41	−0.49	
34	−0.97	−2.13	−2.23	−2.59	
9	−0.70	−0.39	−0.27	−0.60	
57	+3.23	+2.19	+2.14	+2.23	
47	+1.11	−0.07	−0.33	−0.49	
13	+3.04	+2.04	+1.87	+1.79	
21	+4.07	+2.70	+2.66	+2.83	
1	+0.19	−0.44	−0.59	−0.69	
09	+0.39	−1.16	−1.26	−1.33	
71	−2.94	−3.63	−3.97	−3.93	
34	+1.11	+0.16	−0.03	+0.24	
50	−0.21	−1.70	−1.91	−1.50	
74	+1.41	+0.41	+0.33	+0.14	
13	+2.51	+2.93	+2.26	+1.93	
39	+3.43	+2.31	+2.51	+2.43	
21	+0.60	−0.44	−0.40	−0.30	
71	+2.39	+0.11	+0.01	+0.16	
61	+5.07	+4.51	+4.01	+4.20	
10	+0.89	+1.09	−1.13	−1.03	
30	+0.66	+0.37	+0.37	+0.07	
29	+2.94	+1.47	+1.27	+1.40	
6	+1.60	+0.20	+0.26	+0.07	
74	−0.84	−1.76	−1.79	−1.89	
43	+2.91	+0.61	+0.21	+0.24	
14	+0.67	−0.63	−0.96	−1.16	
74	+4.89	+3.41	+3.37	+3.34	
54	+0.13	−1.84	−2.06	−1.53	
79	+1.66	+0.10	−0.29	−0.27	
01	−0.73	−1.26	−1.24	−1.50	
50	+0.31	−1.07	−1.26	−1.26	
30	+1.84	+0.36	+0.04	−0.01	
30	+5.47	+4.66	+4.76	+4.54	
07	+0.29	+0.10	+0.19	+0.36	
79	+1.51	−0.10	−0.23	−0.14	
89	+1.09	−0.47	−0.91	−0.60	
80	+1.90	+0.31	+0.24	+0.54	
27	+3.97	+3.39	+3.27	+3.51	
41	+2.14	+0.71	+0.59	+0.54	
74	−1.63	−1.56	−1.73	−1.99	
17	+1.51	+0.34	+0.20	+0.01	
20	+0.29	−1.21	−1.29	−1.47	
03	+0.60	−1.20	−1.26	−1.04	
46	+2.21	+0.93	+0.71	+0.66	
51	+4.41	+2.09	+1.96	+1.99	
00	−0.71	−0.57	−0.54	−0.99	
30	+1.69	+0.06	−0.06	−0.14	
24	+0.56	−0.17	−0.31	−0.27	
11	+2.56	+1.99	+1.86	+1.60	
73	+1.44	+0.80	+0.80	+0.57	

lics.

HE

REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30, 1905.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

REPORT

OF

THE SUPERINTENDENT OF THE NAVAL OBSERVATORY.

UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., July 1, 1905.

SIR: I have the honor to submit this my annual report of the operations of the United States Naval Observatory for the fiscal year ending June 30, 1905:

PERSONNEL.

The following changes among the officers and employees have occurred since the last report:

Commander J. M. Robinson, U. S. Navy, was detached June 20, 1905.

Lieut. Commander T. D. Griffin, U. S. Navy, reported for duty June 7, 1905.

J. H. Root resigned as assistant April 21, 1905.

G. B. Merriman was promoted from assistant at $1,200 per annum to assistant at $1,400 per annum April 24, 1905.

Arthur Snow was promoted from assistant at $1,000 per annum to assistant at $1,200 per annum April 24, 1905.

H. B. Evans was transferred from assistant to piecework computer September 23, 1904.

A. B. Turner was transferred from computer to miscellaneous computer October 19, 1904.

C. W. Frederick was transferred from assistant on equatorial to assistant astronomer, Tutuila Observatory, naval station, Tutuila, Samoa, August 15, 1904.

E. D. Tillyer was promoted from assistant at $1,000 per annum to assistant at $1,200 per annum September 29, 1904.

W. W. Dinwiddie was promoted from assistant in spectroscopic work to computer October 19, 1904.

Matt Frederickson was transferred from miscellaneous computer to assistant on equatorial August 15, 1904, and was temporarily transferred from assistant on equatorial to miscellaneous computer June 13, 1905.

Arthur Newton was promoted from piecework computer to assistant at $1,000 per annum September 29, 1904.

Charles N. Moore was transferred from miscellaneous computer to assistant in spectroscopic work November 1, 1904.

L. G. Hoxton was appointed assistant on equatorial June 13, 1905.

Edwin C. Howell was appointed miscellaneous computer November 14, 1904, transferred to piecework computer January 21, 1905, and promoted to assistant at $1,000 per annum April 24, 1905.

Asaph Hall, jr., was appointed miscellaneous computer May 6, 1905.

Benjamin Boss was appointed miscellaneous computer June 12, 1905.

J. L. Storla was appointed copyist August 3, 1904.

James H. Nelson was appointed messenger boy January 19, 1905.

Gustave Harrison was transferred from laborer to special laborer, Tutuila Observatory, naval station, Tutuila, Samoa, August 15, 1904.

John K. Throckmorton was appointed laborer July 1, 1904.

John S. Cheek was appointed laborer October 19, 1904.

V. Muehlhaus, jr., was transferred from laborer to watchman, Superintendent's office, State, War, and Navy building, March 13, 1905.

T. G. Wrenn resigned as fireman June 15, 1905.

G. S. Greenly was appointed fireman June 16, 1905.

PLAN OF WORK.

The general plan of the work has continued the same as noted in my last annual report, and is indicated in the following extract from an order issued at the beginning of the fiscal year.

Equatorials.—To make observations of the satellites of Mars, Jupiter, Saturn, Uranus, and Neptune when the planets are not more than three hours from the meridian; satellite work is to take the precedence of all other work; observations of occultations of stars by the Moon; observations of comets; photographic search for asteroids; and observations of double stars in intervals unoccupied.

Meridian instruments.—To make observations of the Sun, Mercury, and Venus at every culmination, except Sunday, whenever possible; of the Moon at every culmination, except between 8 a. m. and 5 p. m. on Sunday, whenever possible; of Mars, Jupiter, Saturn, Uranus, and Neptune, when in the vicinity of the Moon, to the extent of obtaining 30 observations of Mars and 15 each of Jupiter, Saturn, Uranus, and Neptune; of miscellaneous stars when requested; of a catalogue of 3,000 zodiacal stars; and when not interfering with the work above outlined, of stars from Newcomb's Suggested List of Fundamental Stars.

Prime vertical.—To make observations of four groups of stars, four stars in each group, α Lyræ and θ Aurigæ to be included by the polygon method.

Alt-azimuth.—To make observations of the stars of Newcomb's Suggested List of Fundamental Stars culminating here at zenith distances less than 75°.

Photoheliograph.—Daily photographs of the Sun, when possible, with temperature readings and scale settings, and preparation for future eclipse work

ORGANIZATION.

The organization of the Observatory during the past year has been as follows:

OFFICE OF THE SUPERINTENDENT.

Clerk, Thomas Harrison; stenographer, Mrs. A. P. R. Auhagen.

ASTRONOMICAL BRANCH.

A. *Department of astronomical observations.*—Division of equatorial instruments (26-inch and 12-inch equatorials): Professor of Mathematics A. N. Skinner, in charge; Assistant Astronomer H. L. Rice, from July 15, 1904; Assistant Astronomer J. C. Hammond, Computer W. W. Dinwiddie, Assistant on Equatorial C. W. Frederick, to August 15, 1904; Assistant on Equatorial Matt Frederickson, from August 15, 1904.

Division of meridian instruments (9-inch and 6-inch transit circles): Professor of Mathematics W. S. Eichelberger, in charge; Assistant Astronomer H. L. Rice, to July 15, 1904; Computers W. M. Brown

E. I. Yowell, H. R. Morgan, and A. B. Turner, to October 19, 1904; Miscellaneous Computer Asaph Hall, jr., from May 6, 1905.

Division of the alt-azimuth instrument: Professor of Mathematics F. B. Littell, in charge.

Division of the prime vertical transit instrument: Assistant Astronomer G. A. Hill, in charge.

The photoheliograph: Photographer G. H. Peters, in charge.

Librarian W. D. Horigan.

Computers for the department: Computer Eleanor A. Lamson and Miscellaneous Computers Etta M. Eaton, Alice M. Gray, Perez Fisch, Ella A. Merritt, from June 6, 1905, and Benjamin Boss, from June 12, 1905.

B. *Department of the Nautical Almanac.*—Professor of Mathematics Walter S. Harshman, director; Assistants H. B. Hedrick, W. Auhagen, J. Robertson, H. G. Hodgkins, J. H. Root, to April 21, 1905, G. B. Merriman, W. T. Carrigan, H. B. Evans, to September 23, 1904, E. D. Tillyer, A. Snow, A. Newton, from September 29, 1904, and E. C. Howell, from April 24, 1905, and Piecework Computers R. Buchanan, Mrs. E. B. Davis, A. Doolittle, Mrs. H. F. M. Hedrick, R. Keith, Janet McWilliam, T. I. King, A. Newton, to September 29, 1904, and E. C. Howell, from January 21, 1905, to April 24, 1905; Copyist J. L. Storla, from August 3, 1904.

NAUTICAL BRANCH.

A. *Department of nautical instruments.*—Commander J. M. Robinson, in charge to June 20, 1905, Lieut. Commander T. D. Griffin in charge from June 20, 1905; Clerk E. A. Boeger, acting assistant.

B. *Department of chronometers and time service.*—Lieut. Commander E. E. Hayden, in charge; Assistant in Spectroscopic Work C. N. Moore, acting assistant.

C. *Department of magnetism.*—Photographer G. H. Peters, temporarily in charge.

PUBLICATIONS.

During the fiscal year ending June 30, 1905, Volume IV, Appendixes II, III, and IV have been issued.

As showing the contributions to astronomy in general other than that shown in governmental publications, the following list of articles made public is submitted:

In the Proceedings of the United States Naval Institute, Vol. XXX, No. 2, "Work of the Naval Observatory," by Rear-Admiral C. M. Chester, U. S. Navy, Superintendent.

In the Astronomical Journal, No. 567: "Occultations of stars by the moon," by T. I. King and J. C. Hammond.

In the Astronomical Journal, No. 568: "Observations of minor planets and comet *a* 1904 (Brooks)," by J. C. Hammond.

In the Astronomical Journal, No. 569: "Ephemeris of comet *a* 1904 (Brooks)," by Herbert L. Rice.

In the Astronomical Journal, No. 571: "Elements and ephemeris of comet *e* 1904 (Borrelly)," and "Elements and ephemeris of comet *d* 1904 (Giacobini)," by H. R. Morgan and Eleanor A. Lamson; Observations of minor planets," by W. W. Dinwiddie.

In the Astronomical Journal, No. 572: "Elements and ephemeris of comet *a* 1905 (Giacobini)," by H. R. Morgan and Eleanor A. Lamson.

In the Astronomical Journal, No. 574: "Observations of the satellite of Neptune at the opposition of 1904–5," by H. L. Rice and J. C. Hammond.

In the Astronomische Nachrichten, Nr. 3960: "Observations of a new asteroid, 1904 O F," by W. W. Dinwiddie; "Elements and ephemeris of a new asteroid, 1904 O F," by Eleanor A. Lamson.

In the Astronomische Nachrichten, Nr. 3989: "A photographic observation of a minor planet," by G. H. Peters.

In the Astronomische Nachrichten, Nr. 4026: "Observations of the satellites of Saturn and Uranus in 1904," by C. W. Frederick and J. C. Hammond.

In Popular Astronomy, March, 1905: "Elements and ephemeris of comet *d* 1904 (Giacobini)," by H. R. Morgan and Eleanor A. Lamson.

In Popular Astronomy, May, 1905: "Elements and ephemeris of comet *a* 1905 (Giacobini)," by Eleanor A. Lamson.

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

DIVISION OF EQUATORIAL INSTRUMENTS.

This division has continued under the successful management of Professor of Mathematics A. N. Skinner, U. S. Navy.

The distribution of the work of this division has been as follows: Professor Skinner, double stars; Mr. Rice, comets, asteroids, the satellites of Jupiter, Mars, and Neptune; Mr. Hammond, comets, asteroids, the satellites of Saturn and Neptune; Mr. Dinwiddie, asteroids; Mr. Frederickson, comets, occultations, the phenomena of Jupiter's satellites and asteroids.

During the latter part of the year Mr. Dinwiddie has been relieved of observing in order that he might devote his entire time to the eclipse preparations.

As heretofore, Mr. Peters has taken photographs with the 6-inch Dallmeyer camera for assisting in the identification of the fainter asteroids.

Professor Skinner continues to devote the most of his time to work in connection with the preparation of the catalogue of the Astronomische Gesellschaft Zone −13° 50′ to −18° 10′.

Observations have been made in this division during the year as follows:

38 asteroids	204
5 comets	100
Satellites of Mars	2
Satellites of Saturn	218
Satellites of Jupiter	150
Satellites of Uranus	27
Satellite of Neptune	17
Phenomena of Jupiter's satellites	53
Occultations	36
Double stars	67
Photographs for asteroids	49
Miscellaneous stars	13
Total	936

The tables of differential refraction for the latitude of the Naval Observatory, prepared by Mr. Frederick, have been published as

Appendix III, Volume IV, Publications of the United States Naval Observatory, Second Series.

As in former years, the 12-inch equatorial has been devoted one evening a week and occasionally on other special evenings to afford a view of telescopic objects to persons admitted by permit to the Observatory. Mr. Peters was assigned to this duty, which he has performed most ably and acceptably until relieved on May 1 on account of pressing duties in connection with the eclipse expedition. The number of visitors received during the year has been 1,384 on 46 nights.

DIVISION OF MERIDIAN INSTRUMENTS.

This division has remained in charge of Professor of Mathematics W. S. Eichelberger, U. S. Navy, who, as secretary of the committee on editing and printing, also has had charge of the proof reading and the preparation of printer's copy of the department of astronomical observations and such reductions of observations and checking as can not be done in the division in which the observations are made.

As custodian of so much of the Observatory's records and as supervisor of their preparation his duties are most exacting. His administration of the division is highly commended.

The 9-inch transit circle.—This instrument has been devoted to the determination of the right ascensions and declinations of the sun, moon, planets, the stars of Newcomb's Suggested List of Fundamental Stars, and the stars of Gill's Catalogue of 2,798 Zodiacal Stars, with the addition of about 350 stars not in Gill's list in continuance of the plan outlined in the last annual report, which was put into operation on September 3, 1903.

The number of observations from July 1, 1904, to June 30, 1905, is as follows:

Zodiacal stars	3,917
Standard stars	3,919
Screen stars for personal equation	462
Zenith stars for personal equation	293
Astronomische Gesellschaft Zone zero stars	22
Astronomische Gesellschaft Zone zone stars	6
Sun	174
Moon	125
Mercury	57
Venus	114
Mars	30
Jupiter	17
Saturn	15
Uranus	13
Neptune	15
Total	9,179

The number of observers regularly employed during more than half of the year under consideration has been one less than during the preceding year.

Five of the circle microscopes were provided with new objectives by the J. A. Brashear Company (Limited) in May, 1905, as the definition of the old objectives was not good.

Several series of observations by the different observers to determine their personal equations depending on the magnitude of a star by the use of wire-gauze screens were made in April and May, 1905.

A comparison of these results with similar ones determined a year previous indicates that the personal equation due to a change of 2½ magnitudes in the brightness of a star has increased about $0^{s}.01$ in two cases and decreased about $0^{s}.01$ in one case.

Since September, 1903, nine determinations by the use of horizontal collimators of the correction to be applied to observed zenith distances have been made, and the results arranged chronologically are $-1''.09$, $-1''.13$, $-1''.20$, $-1''.30$, $-1''.20$, $-1''.35$, $-1''.43$, $-0''.85$, and $-1''.13$.

The reductions of the observations made with this instrument are getting more and more in arrears for lack of sufficient computing force.

The 6-inch transit circle.—No determinations of position have been made with this instrument during the year.

A discussion of Assistant Astronomer Hammond of about 1,500 observations made by Professor Updegraff and himself in 1901–2 gives the probable error of the mean of four microscopes due to division error $0''.36$ for Circle A and $0''.29$ for Circle B. A discussion by Professor Littell of the observations made in connection with the sun, moon, and planet work gives probable errors of about the same size. These results were obtained with the circles regraduated by The Warner & Swasey Company in 1901, and are somewhat larger than those obtained by Professor Updegraff from the original graduations.

An order has been given to The Warner & Swasey Company, of Cleveland, Ohio, for the construction of a self-registering micrometer of the Repsold type for use with this instrument.

All the observations made with this instrument have been reduced and will appear in the next volume of the Observatory's publications issued from the press.

The standard sidereal clock.—The new sidereal clock, Riefler No. 70, which was sent back to the maker in June, 1904, that the difficulties spoken of in the last report might be corrected, was returned in September, 1904. It has been constantly in use since October 11, and has given perfect satisfaction. From November 20, 1904, to February 2, 1905, assuming the daily clock rate to be $-0^{s}.1648-0^{s}.00064$ (t–Dec. 27.0) the mean residual from a comparison of the observed and the computed clock corrections is $0^{s}.04$. From February 7 to April 16, assuming the daily clock rate to be $-0^{s}.0062+0^{s}.00063$ (t–Mar. 13.0), the mean residual is also $0^{s}.04$.

During the first period the temperature in the clock vault increased gradually about 1° C., while in the second period the temperature decreased gradually about 2° C.

The rates given were obtained by a least square solution of about twenty clock corrections in each group. The barometric pressure in the clock case was changed between the two periods.

General reductions.—The stars, which were omitted from the original observing list of the Astronomische Gesellschaft Zone Catalogue $-13° 50'$ to $-18° 10'$ by mistake, have been observed during the present year. Otherwise all the observations of this zone are reduced to 1900.0, and the precessions and secular variations have been computed for the same epoch. All the stars in Bessel's Zones, in Lalande's Histoire Céleste, in Argelander's Southern Zones, and in the Münchener Sternverzeichniss I and II, and also in the Astronomische Gesellschaft

Zone have been reduced to 1900.0 for purposes of comparison. This work is being carried on under the direction of Professor Skinner, and most of it is being done by him personally.

Since the last report the preliminary revision of the transit instrument zones of the Washington Zone Catalogue has been completed, and the comparison of the zones with the Cordoba General Catalogue has been finished. The same work has been done also for the first year of the meridian circle zones. The zone corrections have been computed for and applied to about nine-tenths of the mural zones. The reduction of the 3,500 unpublished zone observations made with the meridian circle in 1847–48 is about finished. This work is being carried on under the direction of Professor Littell.

Since the last report three appendixes of Volume IV, Publications of the United States Naval Observatory, Second Series, have been published. Appendix II, Reduction Tables for Transit Circle Observations, pages 54; Appendix III, Reduction Tables for Equatorial Observations, pages 101; and Appendix IV, The Present Status of the Use of Standard Time, pages 28. Appendix I, Total Solar Eclipses of May 28, 1900, and May 17, 1901, is at the Printing Office.

DIVISION OF THE ALT-AZIMUTH INSTRUMENT.

This division has been under the charge of Professor of Mathematics F. B. Littell, U. S. Navy, whose official management of it is commended. The determination of the declinations of the stars of Newcomb's Suggested List of Fundamental Stars which culminate here at zenith distances less than 75° has continued as before. The observing list comprises 1,186 stars at the upper and 136 stars at the lower culmination. A few other stars culminating very near the zenith have also been added to the observing list. The number of observations secured during the year is 1,896. Each complete observation furnishes a double zenith distance of the star observed. Readings are made on two circle divisions under each of the microscopes and two alidade levels are used. The observations and their reductions are progressing satisfactorily.

The system of illumination of the microscopes has been changed and made similar to that in use for several years on the 9-inch transit circle. The original system was by central lamp illumination, the light being conducted to each of the four microscopes by a train of mirrors. For this has been substituted a small 3½-volt electric lamp for each microscope operated by battery current. Each lamp is in use only while the microscope is being set, the circuit being closed by a push button pressed by the foot of the observer. The tube which holds the lamp at one end is arranged at the other end to protect the portion of the circle under the microscope from extraneous light, so that in daylight the same illumination is obtained as at night.

DIVISION OF THE PRIME VERTICAL INSTRUMENT.

With the prime vertical instrument Assistant Astronomer G. A. Hill has continued the polygon method of observing. Two changes in the observation of α Lyræ as now used are believed to be advantageous to the work. The first of these is to secure at each culmination of the star transits by direct pointing at the heavens, and also by reflection from a basin of mercury placed upon the floor. The other is to reduce, in the night-time, the brightness of the star's image by means of a wire-gauze screen placed in front of the object glass, giving it the appearance of a sixth magnitude star instead of one of the first magnitude.

Mr. Hill's long and efficient management of this instrument and the large number of observations made by him give him a marked leadership in the use of a prime vertical transit instrument, and astronomers may well expect a most useful addition to astronomical records when the series of observations, which it is hoped will extend through at least one revolution of the moon's node, is published.

The number of observations made during the year is 625.

THE PHOTOHELIOGRAPH.

During the year the sun has been photographed with this instrument on one hundred and sixty-six days and solar spots and faculæ were found on the plates on one hundred and sixty-two days.

While there has been a decrease in the number of photographs secured during this year as compared with the previous one, owing to the unusual amount of cloudiness which has prevailed, Photographer George H. Peters, who has had charge of the instrument, has added a valuable number of observations to the record. The series of photographs secured during several years past gives, with a constantly increasing accuracy, the value of the focal variation due to temperature. The perfection of the solar image upon the photographic plate depends largely upon the atmospheric conditions.

Two enormous groups of solar spots have appeared during the year, and many other large and important groups have been observed in the same period.

The new triple lens of 7½ inches aperture and 65 feet focal length, mentioned in the last report, was received from its makers, the John A. Brashear Company (Limited) of Allegheny, Pa., in April. It was mounted for testing with a view to its use in Spain during the approaching total solar eclipse. Upon the return of the expedition it is intended to mount it to be employed in the daily photographic work on the sun.

The new lens gives an image of the sun's disk about 7 inches in diameter instead of 4¼ inches, as in the photoheliograph at present in use.

Mr. G. F. Coulon has ably assisted Mr. Peters during the past year, and is highly commended by him. During the absence of Mr. Peters from the Observatory on the coming eclipse expedition Mr. Coulon will have temporary charge of the instrument, and thus a complete series of solar photographs will be obtained to be used in connection with the eclipse observations. This is a very important factor, as many coronal features observed at total solar eclipses have an intimate relation with sun spots and faculæ.

LIBRARY.

The library has continued under the successful administration of Librarian W. D. Horigan.

The cataloguing of the library is progressing and with the exception of the serials devoted exclusively to meteorological and magnetic observations the author catalogue is now completed.

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1904	19,276	4,183	23,409
Accessions	420	70	490
Contents July 1, 1905	19,696	4,203	23,899

Of the accessions, 257 were received as exchanges and 233 were purchased.

DEPARTMENT OF THE NAUTICAL ALMANAC.

This department has continued under the direction of Professor of Mathematics W. S. Harshman, U. S. Navy.

There have been received during the year from the Government Printing Office 1,000 copies of the first edition of the American Ephemeris and Nautical Almanac for 1908, 2,300 copies of the second edition of the American Nautical Almanac for 1905, 1,731 copies of the Pacific Coaster's Nautical Almanac for 1905, 702 copies of the second edition of the American Ephemeris and Nautical Almanac for 1905, and 153 copies of the American Ephemeris and Nautical Almanac for 1904.

During the present fiscal year the sale and distribution of publications were as follows:

Title.	Sold.	Public service and exchanges.	Total.
American Ephemeris	766	884	1,650
American Nautical Almanac	2,540	352	2,892
Atlantic and Pacific Coaster's Nautical Almanac	1,451	26	1,477
Astronomical Papers	54	39	93

The proceeds of the sales, amounting to $1,778.90, have been deposited with the Treasurer of the United States to the credit of public printing.

The current work of this department is up to date.

As a result of the recent legislation of Congress, the number of copies of the American Ephemeris provided by law to be supplied to the Navy Department for sale and distribution is inadequate to meet the demands. It has therefore been necessary to supply this deficiency by a requisition upon funds of the Navy Department, although it is specifically provided by law that the proceeds of the sales of these copies shall be deposited to the credit of the general printing fund. It is recommended that legislation be secured for the printing of the full number of copies needed for sale and distribution.

All copy for the Zodiacal Catalogue is in plate, and the volume will be issued as soon as received from the Government Printing Office.

Attention is invited to the fact that, on account of the high scientific attainments required of the assistants in this department, appropriate legislation should be recommended making suitable increase in salaries.

DEPARTMENT OF NAUTICAL INSTRUMENTS.

This department has remained under the efficient charge of Commander J. M. Robinson, U. S. Navy, until June 20, 1905, when his services were required for other duty, much to my regret.

The supply of nautical instruments to ships in commission, or about to be commissioned, to navy-yards and shore stations, wireless telegraph stations, and the naval militia of the various States has proceeded regularly and promptly in accordance with shipment orders received. In addition two complete surveying outfits have been issued, and this department is now engaged in assembling two new surveying outfits to replace the two issued. Owing to the great pressure of routine work, this undertaking is proceeding very slowly.

The stock of nautical instruments has been kept up to the authorized amount by the acquisition of additional instruments on requisitions, which instruments have been inspected, tested, and stored as received.

The clerical work involved in keeping the fleet supplied with nautical instruments is very heavy, is increasing rapidly, and is already more than one man can accomplish alone. In consequence the officer in charge has constantly to devote the major part of his time to the preparation of routine papers to the exclusion of work of a more important character, such as the study of nautical and surveying instruments and their suggested improvements. I beg to invite your attention again to the urgent need of increased expert and clerical assistance in this department of the Observatory, the work of which is increasing with the growth of the fleet to such an extent that it is impossible with the present force to devote that time and attention to the inspection of nautical and surveying instruments which instruments of such a character demand.

There is constantly in stock at the Observatory in the instrument room, in the chronometer room, and in the storeroom approximately $100,000 worth of instruments. The officer in charge of this department is responsible for these instruments and has as a care taker or storekeeper only a laborer detailed for that purpose who is also charged with the work of packing and shipping all instruments issued and unpacking and storing those received. The laborer detailed for this work, Mr. John Brockman, is eminently qualified therefor. He is careful, thorough, methodical, and reliable, and his services are of great value in this department.

During the year considerable correspondence has been carried on with several of the American makers of optical instruments in an effort to induce them to take up the manufacture of binoculars and spyglasses for marine use in the hope of securing a better class of these instruments than is at present supplied by the importers. The greatest difficulty with which the American manufacturers of optical instruments have to contend is the cost of production, due to the high price of labor. The difference in cost, however, in favor of the foreign maker becomes less as the character of the work improves, and it is believed that by demanding optical instruments of the highest class and finest finish the American manufacturers will be encouraged to compete with the foreign maker. In the manufacture of prismatic binoculars two American firms are already competing successfully with the foreign makers.

The number of shipments made during the year was 395, amounting in value to $99,146.80.

The value of instruments received during the year was, by purchase, $23,675.09, and by return from navy-yards, etc., $44,688.76.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department has remained in charge of Lieut. Commander E. E. Hayden, U. S. Navy, assisted by Mr. C. N. Moore.

The routine work, consisting of the trial, care, and rating of naval chronometers, watches, and clocks, their issue, with the necessary data and forms, to naval vessels, the supervision of their repairs, and the sending out of the daily telegraphic noon signals, has been carried on very successfully in spite of the small available office force and the increasing demands of the Navy.

The regular annual chronometer trial began in January with 40 new chronometers, 31 new torpedo-boat watches, 84 old chronometers, 5 old torpedo-boat watches, and 1 old chronometer watch. This trial consisted of three separate trials, but all went on together for six months—three months in the temperature room and three months in the chronometer room—in accordance with the terms of the Bureau's specifications No. 25 of May 15, 1903, and No. 269 of February 26, 1904. There were also on hand at the beginning of the trial 28 other chronometers and watches, making in all 189 chronometers and watches that were wound and compared daily, their rates being computed, recorded, and plotted weekly.

The results of the three trials are given in the appended tables, trial numbers above 25 being omitted:

TABLE I.—Trial of new American chronometers with steel hair springs and ordinary balances.

TABLE II.—Trial of new torpedo-boat watches.

TABLE III.—Trial of old naval chronometers.

The amount of careful expert work involved in connection with this trial will be better appreciated when it is remembered that the Superintendent of this Observatory in 1886 stated in an official report (Appendix III to Washington Observations for 1883) that "the example of the computation of a trial number given will serve to give some idea of the amount of labor involved in this test of more than 50 chronometers; when to this are added the voluminous records necessarily kept it will be seen that this duty involves no light work." It need only be added that there are at present three times the number of chronometers and only two-thirds as large an office force in this department of the Observatory. Its increased efficiency has resulted largely from improved methods devised by the officer now in charge.

The accuracy of the time service has now become almost perfect, the maximum error of the daily noon signals for the month of April, for instance, having been only $0^s.06$ and the mean daily error for that month only $0^s.017$, the best monthly record ever made at this Observatory.

The usual special series of midnight New Year's eve telegraphic time signals were sent out, and two other special series of midnight signals, the first on September 8 in honor of the International Geographic Congress, and the second on May 3 in honor of the International Railway Congress. All of these special series of time signals were transmitted far and wide through the voluntary cooperation of various telegraph, cable, and telephone companies, and excited international interest and attention. Their effect, based as they are upon Greenwich standard time and enlisting, as they do, the assistance of governments, companies, and observatories all over the world, is thought to add a powerful influence toward the universal adoption of Greenwich standard time and longitude.

The following reports of the time of transmission of these special time signals, selected from among the many received, will serve to illustrate their accuracy and rapidity in spite of the relays and manual repetitions that are necessary on very long lines.

Quickest reported times of transmission of time signals from the Naval Observatory.

Locality.	Time of transmission.
	s.
McGill College Observatory, Canada	0.00
Toronto Observatory, Canada	0.00
Santa Clara College Observatory, California	0.04
Lick Observatory, California	0.05
Chamberlin Observatory, Colorado	0.07
Ladd Observatory, Rhode Island	0.07
Washburn Observatory, Wisconsin	0.09
Amherst College Observatory, Massachusetts	0.10
Chabot Observatory, California	0.10
Goodsell Observatory, Minnesota	0.10
Harvard College Observatory, Massachusetts	0.10
St. John Observatory, New Brunswick	0.11
Tacubaya Observatory, Mexico	0.11
Coast and Geodetic Survey station, Seattle, Wash	0.29
Manila Observatory, Philippine Islands	0.37
Mare Island Observatory, California	0.37
Roman College Observatory, Italy	1.10
Greenwich Observatory, England	1.33
Hamburg Observatory, Germany	1.47
Coast and Geodetic Survey station, Alaska	1.70
Sydney Observatory, Australia	2.25
Survey Office, Brisbane, Australia	2.45
Adelaide Observatory, Australia	2.96
Wellington Observatory, New Zealand	4.00
Cordoba Observatory, Argentina	7.70

The special midnight time signals sent out on May 3 were displayed very effectively by means of a very large map of the world, 21 by 42 feet, erected on the grounds of the Railway Appliance Exhibit, near the Washington Monument, with small electric lights arranged to mark the exact positions of more than 200 of the principal cities of the world. The lights in the United States were illuminated each second by our standard clock and the final midnight signal was made to spread rapidly over the world, exactly as actual reports have indicated. The Secretary of the Navy turned on the current at five minutes of 12, and the large audience that was present watched the demonstration with the greatest interest. The same map was used in a similar way at 8, 9, and 10 p. m. on several subsequent evenings, and proved to be one of the most attractive features of the exhibit.

On March 11, a new time-ball went into operation at Pittsburg, Pa., making 19 in all in the United States. This new time-ball was installed by the Farmers' Deposit National Bank on the roof of their 24-story building, and is operated with the cooperation of this Observatory, the Western Union Telegraph Company, and the United States Weather Bureau. Its elevated location, 400 feet above the ground, which enables it to be seen from all parts of the city and from the adjacent rivers and surrounding country, will undoubtedly serve to make it very useful to business men and inland commerce generally.

Three copper-covered, asbestos-lined chests, each fitted to take three chronometers in their boxes and transporting cases, have been made for trial during the eclipse expedition and, if approved, for subsequent use at sea. The advantage of such chests over the chests now in use is that, while no larger than the latter, they allow of the constant use of the ordinary chronometer-transporting cases for the increased protection of the chronometers, and are of practically fireproof construction. For convenience and safety in carrying chronometers to and from the Observatory, a special padded leather carrying case or valise has been added to the equipment of this department, in which nine chronometers, each in a corrugated paper box, can be carried with very little liability to injury or of disturbance of their rates.

A monograph on the "Present Status of the Use of Standard Time" was prepared by Lieutenant Commander Hayden and published as Appendix IV, Volume IV, of the Publications of the Observatory. This publication contains official data regarding the kinds of time in actual use by all of the principal nations of the world, collected for this Observatory by the Department of State through the diplomatic and consular service and the Office of Naval Intelligence, Bureau of Navigation, through the naval attachés, together with tables for the ready conversion of the time of one country into that of another.

BRANCH OBSERVATORY AT TUTUILA, SAMOA.

Mr. C. W. Frederick, assistant on equatorial at the Observatory, was appointed an assistant astronomer, naval station, Tutuila, Samoa, on July 18, 1904, and Mr. Gustave Harrison, laborer, was at the same time appointed care taker. They were ordered by the Department to proceed from San Francisco on September 8, to Tutuila, and report to the commandant at that station for the purpose of erecting an astronomical observatory. They arrived at Tutuila on September 21.

Upon recommendation from the Superintendent the Department authorized the purchase of the necessary material for the construction of the transit circle house, the clock house and observer's office, and dwellings for the observer and his assistant.

Mr. Frederick has submitted reports to the commandant, naval station, Tutuila, which have been referred to the Superintendent of the Naval Observatory, giving the course of construction. In a report recently submitted he states that the transit circle house and the clock house, which is to be one in which a constant temperature can be obtained, are practically completed together with the necessary piers, and that he was ready to mount the instruments. It is thought that astronomical observations will soon be begun, furnishing data which is much needed covering a zone from the south pole to beyond the zenith of Washington.

BUILDINGS.

The buildings belonging to the Government within the Naval Observatory Reservation are in generally good condition, but owing to the fact that the transit houses are of iron construction, from which paint peels off in warm weather, it will soon be necessary to give them another coating of that material to keep them from serious deterioration.

MACHINE SHOP.

Last year there was installed a small machine shop at practically no expense, as for its equipment there was used condemned material collected from various navy-yards. During the present year the great usefulness of this shop has been shown and the desirability of its further development has become apparent. Mr. W. W. Dinwiddie, computer, was placed in charge of the shop, and with the assistance of Mr. H. C. Cleve, instrument maker, has constructed there many of the instruments for observing the solar eclipse of August next. Had it not been possible to do this work in the shop it would have taken nearly the whole eclipse appropriation to have secured the instrumental equipment necessary.

I hope in the future to be able to take up the question of enlarging the shop, as experience has demonstrated that it will lessen the expenses for repairs and construction of instruments, as well as permit more prompt attention to such work than can be had when dependence is placed upon instrument makers in other cities.

I wish to record here my appreciation of the services of Mr. Dinwiddie, who has been chiefly concerned with the development of this work, and to whose industry and skill in construction the completeness of the eclipse instrumental equipment is due. As showing what has been done in this respect I feel warranted in quoting from a letter recently received by the Superintendent from the manager of one of the largest instrument works of the country, whose reputation is world-wide, as follows:

> I had the pleasure of looking over your apparatus (preparing for observing the eclipse of the sun on August 30, 1905), with which I was much impressed, as it seemed to me particularly well designed and very efficient.

PHOTOGRAPHIC EQUATORIAL.

During the year Mr. Dinwiddie has taken from the scrap heap of old iron the mounting formerly used for the 26-inch equatorial at the old Observatory and fitted it up with the framework of an obsolete 9-inch telescope, which is to carry two Dallmeyer lenses for photographing asteroids. Over this there has been constructed a house designed and largely built by him which will answer all purposes for carrying on this important branch of astronomical work. It is thought this plant will compare favorably with any other that could be duplicated for $10,000 or $15,000. As soon as the Observatory force is relieved from the duty of making preparations for and of observing the next solar eclipse, it is expected that good results will accrue from this plant.

GROUNDS AND ROADS.

I have to renew the recommendation contained in my last annual report that early steps be taken to acquire the property lying within the Observatory Circle, as contemplated by the joint resolution of Congress approved August 1, 1894. The question of the transfer of the tract of land belonging to Mr. Philip Young and of that belonging to the Normanstone estate still remains in the District courts, and will probably be settled by the time it is necessary to get the ground in shape to harmonize with the other public property. The property belonging to the District of Columbia, known as the Industrial Home

TABLE I.—*Tabular statement of data of competitive tri*

Temperature, by thermometric chronometers..................................degr

Relative humidity, by sling psychrometer..................................per

Order of merit.	Balance: o=ordinary. a=auxiliary. c=corrector. v=invar. Hairspring: s=steel. p=palladium. l=alloy, composition unknown.			Trial number.	Point of compensati		
					Temperature.	Rate.	Ter tur st
					°	s.	
1	Bond	517	o. s.	11.91	66.9	+0.24	+0
2	....do	526	o. s.	12.26	69.8	−0.56	+0
3	Negus	2050	o. s.	12.89	68.1	−0.75	+0
4	Bond	574	o. s.	18.75	59.6	+0.53	+0
5	Negus, M. T. B. C	2045	o. s.	18.79	63.5	+2.63	+0
6	Negus	2054	o. s.	20.96	67.9	−0.48	+0
7	Negus, M. T. B. C	2046	o. s.	21.93	72.1	+1.39	+0
8	Bond, M. T. B. C	452	o. s.	22.39	70.5	−0.35	+0
9	Negus, S. B. C	1928	o. s.	22.43	65.9	+1.31	+0
10	Negus	2042	o. s.	25.24	68.8	−0.14	+0
11	Bond	603	o. s.	25.35	66.3	+1.01	+0

13737—05 (To face page 17.) No. 1.

UNIV. OF MICH.

e tri

..degr

...per

nsati

Ten
tur
st

+0
+0
+0
+0
+0
+0
+0
+0
+0
+0
+0

TABLE II.—*Tabular statement of data of competitive tria*

Temperature, by thermometric chronometers..................................degre

Relative humidity, by sling psychrometer..per

Order of merit.	Balance: o=ordinary. a=auxiliary. c=corrector. v=invar.	Hairspring: s=steel. p=palladium. l=alloy, composition unknown.		Trial number.	Point of compensatio		
					Temperature.	Rate.	Tem ture sta
					°	s.	s
1	Nardin................	10977	v. s.	5.45	83.5	−1.25	– .
2	.....do....................	10811	v. s.	7.75	58.3	−1.95	–.
3	.....do....................	10669	v. s.	12.65	126.0	+0.27	–.
4	.....do....................	10972	v. s.	13.84	64.9	−1.85	.
5	.....do....................	10976	v. s.	15.75	73.1	+1.73	–.
6	.....do....................	10974	v. s.	16.86	73.6	−2.70	–.
7	.....do....................	10807	v. s.	20.07	62.3	−0.63	+.
8	Patek, Philippe & Co...	119091	o. s.	21.30	78.2	−4.31	+.
9	.....do....................	119093	o. s.	23.58	80.6	−3.66	+.

13737—05 (To face page 17.) No. 2.

UNIV. OF MICH.

ve trial

N

....degre

.....per c

pensation

	Temp ture sta
	s
5	−.0
5	−.0
7	−.0
5	+.0
3	−.0
0	−.0
3	+.0
	+.0
	+.0

TABLE III.—*Tabular statement of d*

N

Temperature, by thermometric chronometers..................................degrees

Relative humidity, by sling psychrometer..per c

Order of merit.	Balance: o=ordinary. a=auxiliary. c=corrector. v=invar.	Hairspring: s=steel. p=palladium. l=alloy, composition unknown.		Trial number.	Point of compensation.		
					Temperature.	Rate.	Temperature c stan
					°	s.	s.
1	Negus	1986	o. p.	3.25	77.3	−1.05	+0.0
2	Leroy	916	o. p.	3.42	111.2	−0.08	+0.0
3	.....do	999	v. s.	5.82	439.8	+5.26	−0.0
4	Negus	2034	o. l.	6.85	85.7	−0.32	+0.0
5	.....do	863	o. s.	8.57	66.3	+0.30	+0.0
6	Bond	493	a. s.	9.45	76.9	−0.62	+0.0
7	Negus, Sid	1877	o. s.	9.73	64.7	+0.49	+0.0
8	Adams	5592	o. s.	10.05	71.2	+0.77	+0.0
9	Johannsen	4647	a. s.	10.71	81.2	−0.34	+0.0
10	.....do	4635	a. s.	10.80	77.8	+0.34	−0.0
11	Negus	1758	o. s.	11.42	66.5	−1.11	+0.0
12	Bond	294	a. s.	11.79	66.3	−2.19	+0.0
13	Negus	1820	o. s.	11.93	70.1	+0.61	+0.00
14	Leroy, S. B. C	998	v. s.	12.19	104.2	+1.66	−0.00
15	Bond	272	a. s.	12.63	53.0	+0.22	+0.0
16	Negus, Sid	1565	o. s.	12.90	64.7	−0.96	+0.0
17	U. & C	464	c. s.	13.55	68.8	+1.60	+0.00
18	Negus	1765	o. s.	13.82	73.6	−1.63	+0.00
19	.....do	1283	o. s.	14.58	65.1	+1.58	+0.00
20	Bond	221	a. s.	15.49	63.8	−0.81	−0.00
21	Negus	1343	o. s.	15.83	69.6	−0.44	+0.00
22	.....do	1899	o. s.	15.87	72.3	+0.28	+0.00
23	Negus, S. B. C	1518	o. s.	16.09	64.0	+1.95	+0.00
24	Bond	339	o. s.	16.62	61.6	−1.20	+0.00
25	Bliss	2938	o. s.	17.10	63.2	−0.38	+0.00
26	Barraud	2077	o. s.	18.00	75.5	+1.48	+0.00
27	Bond	558	o. s.	19.28	65.3	−0.18	+0.00
28	Negus, S. B. C	1527	o. s.	20.04	56.8	−2.97	+0.00
29	Negus	1464	o. s.	20.14	73.3	−0.27	+0.00
30	.....do	1657	c. s.	20.73	76.8	−0.66	+0.00
31	.....do	1636	o. s.	21.83	64.9	+1.08	+0.00
32	.....do	1674	o. s.	22.10	69.0	−0.93	+0.00
33	Bond	283	a. s.	23.43	49.4	−1.36	+0.00
34	Riggs	5630	a. s.	23.98	64.1	−3.87	+0.00
35	Bliss	2977	o. p.	24.48	59.8	−0.08	+0.00
36	Negus	1097	o. s.	24.88	67.8	+0.34	+0.00

UNIV. OF MICH.

however, should receive early attention. The Navy Depart-
d the District Commissioners have practically come to an
nt as to the price to be paid for this property, as shown in
ort to which reference was made a year ago, but as two or
ears will be required for the school to be established elsewhere
e necessary, in order to carry out the will of Congress in the
ture, to submit to that body an estimate for the purchase of
perty at an early date.

ongress has, in the appropriation bill providing for the expenses
Naval Observatory for the fiscal year 1905–6, restored the item
,000 for the care and grading of the grounds, which accords with
propriation which existed up to July 1, 1902, it is expected that
ter the grading of the ground within the Observatory limits can
ried on coincidently with that of the adjoining thoroughfares by
istrict government.

APPROPRIATIONS.

el it my duty again to call the attention of the Department to
otally inadequate force which is allowed by Congress to carry on
ork of the Observatory. My last annual report treats this sub-
n extenso, and I urgently appeal for at least a gradual increase in
ersonnel which will permit the proper execution of the important
s devolving upon the staff and prevent the oft-repeated but
unded charge of inadequate amount of work for so large an
tution.

Very respectfully, your obedient servant,

C. M. Chester,
Rear-Admiral, U. S. Navy,
Superintendent of the Naval Observatory.

he Chief of the Bureau of Equipment,
Navy Department.

O

SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30, 1906.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

SYNOPSIS OF THE REPORT

OF THE

SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30, 1906.

Rear-Admiral Colby M. Chester, U. S. Navy, was Superintendent of the Naval Observatory until his retirement on February 28, 1906. Rear-Admiral Asa Walker, U. S. Navy, assumed the duties of Superintendent on March 1, 1906.

DEPARTMENT OF NAUTICAL INSTRUMENTS AND GENERAL STOREKEEPER.

This department was in charge of Commander T. D. Griffin, U. S. Navy, until the end of May. During June Lieut. Commander E. E. Hayden, U. S. Navy, was in charge.

The number of shipments made during the year was 400, amounting in value to $96,713.12. The value of the instruments received was, by purchase, $34,758.01, and by return from navy-yards, $84,383.66. The value of the stock on hand is $97,129.32.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department was temporarily in charge of Mr. E. A. Boeger, assistant in department of nautical instruments, until December 26, 1905, when Lieut. Commander E. E. Hayden, U. S. Navy, returning from the eclipse expedition, resumed charge.

The regular annual chronometer trial began on January 10, with the largest number of chronometers and torpedo-boat watches ever entered in such trial at this Observatory, namely, 42 new marine chronometers, 57 new torpedo-boat watches, 74 old chronometers, and 7 old watches, and more chronometers and watches were added as they were returned, cleaned, and repaired from the makers. The trial ended on June 11.

The accompanying tabular statements, Tables I, II, and III, give all the data and results of the trial for those instruments that were successful in obtaining a trial number of 25 or better, that being the highest allowed for new chronometers and watches.

An important amendment to the current specifications, No. 25, of May 15, 1903, for new chronometers, was recommended during the trial, accepted by the makers, and adopted by the Bureau of Equipment, as follows:

In case a new chronometer obtains a trial number greater than 25 in any trial held according to these specifications, and in case such chronometer has shown an actual acceleration of rate from the first to the second of the two observed mean daily temperature-room rates at 85° F., 70°, and 55°, respectively, its trial number shall be recalculated with an allowance for such acceleration to be determined and applied as follows: From the two observed temperature-room rates at 85° F., 70°, and 55°, respectively, calculate the mean daily acceleration at each of those temperatures; take the mean of these three means as the mean daily acceleration, or coefficient of time, of the chronometer; then, beginning with the first observed rate in the trial, apply this coefficient to all of the succeeding observed rates of the chronometer in order to reduce them for such assumed acceleration; finally, with these corrected rates calculate a new trial number; if such new trial number be less than 25 it shall be stated as 25.00 A in the final report of the trial, in place of the trial number that was first obtained; all other data and results of the trial, however, shall be of record as actually observed and calculated, according to the specifications.

The regular work of the department in connection with the rating and issue of chronometers, the testing of new chronometers, watches, and clocks, and the sending out of the daily telegraphic time signals has been heavier than usual during the year, as shown by the following brief summary, which, of course, does not include any account of the voluminous records and correspondence in connection therewith:

Number of chronometers received	215
Number of chronometers sent out	236
Number of watches received	264
Number of watches sent out	196
Number of stop and comparing watches tested	83
Number of deck and boat clocks tested	417

There were in the naval service at the close of the fiscal year 651 chronometers and 78 torpedo-boat watches, of an aggregate value of about $200,000, every one of which is either actually in use in navigation or being cleaned, repaired, and accurately rated for such use. The history of each is recorded very carefully, its location and condition are always known, and its performance at sea and at the Observatory must be observed and compared constantly in order to maintain the standard required for accurate navigation. Those that fail must be replaced by other and better ones and a reserve kept on hand ready for emergencies. All of this work is imperatively demanded by the sea going vessels of the Navy, and is now, and always has been, one of the most important duties of this Observatory. Incidently to this chronometer service, which, of course, always requires the most exact time, the telegraphic time service developed; and with no additional expense or trouble to the Navy the entire country is supplied, by means of the voluntary cooperation of the telegraph and telephone companies, with exact standard time daily. The mean daily error of the noon signal for the year is $0^s.045$, the maximum error on any day being $0^s.29$.

The attention of the Department is called to the need of an additional officer in this department and one also in that of nautical instruments. The work in each of these departments has increased more than twofold since just before the Spanish war, while the working force has not been enlarged.

COMPASS OFFICE.

This office was in charge of Commander George H. Peters, U. S. Navy, to November 13, 1905, and since that date has been in charge of Lieut. Commander, John M. Ellicott, U. S. Navy.

This office was transferred to the Observatory on January 19, 1906, where the work of instruction to officers has since been conducted as well as the other official work of the office.

The superintendent of compasses points out the desirability of the assignment of a competent officer as an assistant in the office to relieve him when detached and to assist in the work of the office; also the need of a clerk for the office.

The supply of compasses and materials connected therewith has been sufficient to meet the current demands, but only a small supply in excess is on hand to meet an emergency.

Various improvements have been made in the instruments connected with this branch of navigation and instructions given as to their use. Valuable results have been obtained from the reports of navigators in the process of correcting variation on charts.

Special efforts have been made to determine the most suitable locations for compasses on board ships and submarines.

In connection with this report, the need of a separate building for the mounting of the Scorsby model, so that students may be able to utilize the sun for several hours of the day for compass observation, is strongly recommended.

NAUTICAL ALMANAC OFFICE.

This office has continued under the direction of Professor of Mathematics W. S. Harshman, U. S. Navy.

There have been received during the year from the Government Printing Office 705 copies of the first edition of the American Ephemeris and Nautical Almanac for 1906, 118 copies of the second edition of the American Nautical Almanac for 1905, 101 copies of the first edition of the American Ephemeris and Nautical Almanac for 1905, 1,727 copies of the first edition of the Pacific Coaster's Nautical Almanac for 1906, 500 copies of the first edition of the American Nautical Almanac for 1908, 2,549 copies of the first edition of the American Nautical Almanac for 1906, and 350 copies of the second edition of the American Ephemeris and Nautical Almanac for 1906.

During the present fiscal year the sale and distribution of publications were as follows:

Title.	Sold.	Public service and exchanges.	Total.
American Ephemeris and Nautical Almanac	874	940	1,814
American Nautical Almanac	2,714	326	3,040
Pacific Coaster's Nautical Almanac	1,353	48	1,401
Astronomical Papers	51	28	79

The proceeds of sales, amounting to $1,933.28, have been deposited with the Treasurer of the United States to the credit of public printing.

The current work of this office is up to date. The ephemeris of Phoebe, the ninth satellite of Saturn, is now given for the first time in the American Ephemeris.

THE DIVISION OF EQUATORIAL INSTRUMENTS.

This division has continued in charge of Professor of Mathematics A. N. Skinner, U. S. Navy.

The following observations have been made in this division during the year:

Satellites of Saturn	210
Satellites of Uranus	12
Bright satellites of Jupiter	58
Sixth satellite of Jupiter	9
Satellite of Neptune	30
5 comets	50
66 asteroids	302
Occultations of stars by the Moon	26
Photographs for asteroids	12
Miscellaneous observations	45
Total	754

It is the aim of the division of equatorial instruments to make measurements of position of comets, asteroids, and the satellites of the planets, and to observe the occultations of stars by the moon, which are predicted in the American Ephemeris. Determinations of several orbits of comets and asteroids have been made.

DIVISION OF MERIDIAN INSTRUMENTS.

This division has continued in charge of Professor of Mathematics W. S. Eichelberger, U. S. Navy.

During the absence of Professor Eichelberger in Europe, Professor Skinner was in charge of this division for the first five months of the year.

The 9-inch transit circle.—The plan of work decided upon for this instrument in the fall of 1903 has been continued during the year just ended.

The number of observations from July 1, 1905, to June 30, 1906, is as follows:

Zodiacal stars	2,062
Standard stars	3,819
Screen stars for personal equation	235
Zenith stars for personal equation	80
Sun	131
Moon	102
Mercury	29
Venus	82
Jupiter	16
Saturn	15
Uranus	8
Neptune	15
Total	6,594

The decrease in the number of observations as compared with the preceding two years is due to the five months' absence of Professor Eichelberger and Mr. Yowell, and to the suspension of regular observing work during May to permit of a determination of the errors of the circle graduations.

Three determinations of the horizontal flexure indicate no change from the values obtained during preceding years. Several determinations of the vertical flexure have been obtained by the use of a vertical collimator, giving a flexure of about 1″.

During the month of May four observers were engaged in the determination of the division errors of the circle graduations. A separate determination was made by each observer. Of the 180° diameters the errors of all multiples of 5° and of half of the remaining 144 diameters were completed. The errors of the remaining 72 diameters were determined by two of the observers, and will be determined during the summer by two others. At the same time the errors of the half-degree diameters will also be determined. The error of each diameter is thus determined independently four times, and the maximum range in any one of the 107 sets of four so far completed is 0″.34, and the mean probable error of the finally adopted corrections is less than 0″.025.

The reductions of the observations made with this instrument are badly in arrears for lack of sufficient computing force.

The 6-inch transit circle.—The final adoption of the plans for the self-registering right ascension micrometer for this instrument was postponed until the return of the recent eclipse party so that the results of observation at the European observatories might be available. The micrometer is now being constructed by the Warner & Swasey Company, of Cleveland, Ohio.

Astronomische Gesellschaft Zone Catalogue —13° 50′ to —18° 10′.—The different positions of each star in this zone as given in the four catalogues mentioned in the last annual report have been gathered together through the first ten hours of right ascension for a discussion of proper motion. It is hoped to finish this work for the remaining fourteen hours during the coming year and to prepare the printer's copy for the final catalogue. This work is being carried on under the direction of Professor Skinner and much of it is being done by him personally.

Washington Zone Catalogue.—During the present year the individual transit threads have been reduced to mean thread for almost all the zones. A number of discordant threads have thus been located, many wrong means have been discovered, and 48 transit zones have been found to have been reduced with incorrect thread intervals. Of the unpublished zone observations the 400 mural circle observations made in 1851 are now being reduced. The reduction of these unpublished zone observations is being carried on under the direction of Professor Littell.

Printing.—Since the last report, Appendix I, Volume IV, Publications of the United States Naval Observatory, Second Series: Total Solar Eclipses of May 28, 1900, and May 17, 1901, has been published. The completed Volume IV, containing all the meridian circle work to September, 1903, not heretofore published, together with a re-reduction by Prof. John R. Eastman, retired, of the observations of the sun, moon, planets, and comets, 1866–1891, is now in press.

DIVISION OF THE ALT-AZIMUTH INSTRUMENT.

This division has continued in charge of Professor of Mathematics F. B. Littell, U. S. Navy.

The instrument has been used as a vertical circle for determining the declinations of the stars of Newcomb's Suggested List of Fundamental Stars, which culminate here at zenith distances less than 75°. The observing list comprises 1,186 stars for upper culmination and 136 stars for lower culmination. Each complete observation furnishes a double zenith distance of the star observed. Readings are made on two circle divisions under each of the four microscopes, and to facilitate this operation an extra set of double threads has been placed in each microscope at a distance of 2.5 revolutions of the micrometer screw from the original set. By this arrangement the principal periodic errors of the micrometer screws are also eliminated.

The number of star observations made during the year was 899. Some preliminary work has also been done in examining the division errors of the circle. The one observer attached to the instrument was absent from the Observatory for several months on eclipse duty in Spain and elsewhere.

The reductions are in a satisfactory state of progress.

A new building is urgently needed for this instrument. The present one was intended only as a temporary one, and it is very poorly adapted to the uses of the instrument.

DIVISION OF THE PRIME VERTICAL INSTRUMENT.

This division has continued in charge of Assistant Astronomer G. A. Hill, who was absent from the Naval Observatory on eclipse duty from July 1 to October 10, 1905.

Observing with this instrument has been continued by the method outlined in former reports. The total number of observations now made with this instrument and awaiting publication is 4,507, of which 1,282 are of *α* Lyræ. The number of observations made during the past year, comprising slightly less than nine months of observing, is 392.

The observations are completely reduced to April 30, 1905, and the reduction of those made since that time is well in hand.

THE PHOTOHELIOGRAPH.

This instrument has continued in charge of Photographer G. H. Peters during the year. During his absence on the eclipse expedition from July 1 to October 10, 1905, Mr. G. F. Coulon was temporarily in charge.

Photographs of the sun have been obtained on one hundred and sixty-eight days, on one hundred and sixty-six of which solar spots and faculæ were observed on the plates, including many large and important groups of spots.

THE LIBRARY.

The library has continued in charge of the librarian, W. D. Horigan.

	Volumes.	Pamphlets	Total.
Contents of the library July 1, 1905	19,696	4,203	23,899
Accessions	749	73	822
Contents July 1, 1906	20,445	4,276	24,721

Of the accessions 285 were received as exchanges and 537 were purchased.

Among the books purchased were a set of the Compte Rendu de l'Association Francaise pour l'Avancement des Sciences, Session 1–32, 1873–1903, in 51 volumes, and a set of the Nouvelles Annales de

Mathematiques (Terquem et Gerono), Vols. 1-62, Paris, 1842-1903. The number of volumes bound for the library was 400.

There were distributed 2,064 copies of the various publications of the Observatory.

The routine work of the library is up to date.

THE TOTAL SOLAR ECLIPSE OF AUGUST 30, 1905.

The work on astronomical observations was much reduced by the absence of all but one of the regular heads of divisions, with several of their assistants, for periods ranging from four to six months, on the total solar eclipse expedition of 1905. Rear-Admiral Chester, late Superintendent of this Observatory, had personal charge of this expedition, and is now engaged in making out a full report of the same. His preliminary report is published in the Astrophysical Journal.

PUBLICATIONS.

During the fiscal year ending June 30, 1906, Volume IV, Appendix I, has been issued. The completed Volume IV, containing about 800 pages, is now being bound at the Government Printing Office.

As showing the contributions to astronomy in general in other than Government publications, the following list of articles made public is submitted:

In the Astrophysical Journal of March, 1906: "Preliminary results of the United States Naval Observatory Eclipse Expedition in 1905," by Colby M. Chester.

In Popular Astronomy for August and September, 1905: "The requisites of a transit observer," by Geo. A. Hill. "A differential method generally applicable to all solutions proceeding by successive approximations, and especially available when these approximations practically fail to converge," by Herbert L. Rice.

In Popular Astronomy for October, 1905: "An untried method of determining the constant of refraction," by Geo. A. Hill.

In Popular Astronomy for May, 1906: "Given the elements of an asteroid to compute, differentially, its daily motion in geocentric right ascension," by Herbert L. Rice.

In the Astronomische Nachrichten, Nr. 4029: "Elements of (532) Herculina and ephemeris for opposition of 1905," by J. C. Hammond.

In the Astronomische Nachrichten, Nr. 4050: "Provisional elements of 1905 QU," by J. C. Hammond.

In the Astronomical Journal, No. 580: "Elements and ephemeris of comet *b* 1905 (Schaer)," by Eleanor A. Lamson.

In the Astronomical Journal, No. 583: "Elements and ephemeris of comet *a* 1906 (Brooks)," by Eleanor A. Lamson.

In the Astronomical Journal, Nos. 584-585: "The proper motion of B.D.$+38^\circ$ 3095," by Geo. A. Hill.

Also numerous observations of satellites, asteroids, comets, and occultations of stars by the moon.

BUILDINGS, GROUNDS, AND ROADS.

The buildings are generally in good condition, and the roads are well kept.

Grading has been continued on the northeastern portion of th grounds and on the hill at the southwest on plat purchased from Mr Theo. Barnes. The plat formerly owned by Mr. Philip Young ha been acquired and title completed. Fifty-three hundred and forty-tw feet of wire fence have been erected under contract, No. 7164, of Jun 22, 1905, with the New Jersey Foundry and Machine Company.

After consultation with the District Commissioners, a bill was framed and introduced in the Senate, S. 5873, for the acquisition of the property known as the Industrial Home School property. The acquisition of this property is deemed very desirable in order that objectionable features now prevalent in that locality may be removed, and, incidentally, needed accommodations for observers may be obtained.

The plat of 1.732 acres, a part of the property known as "Normanstone," still remains to be acquired, and proceedings for its condemnation are before the court. It seems desirable that these proceedings be expedited and title to the property obtained.

The Superintendent renews the recommendation of a former Superintendent that none of the property belonging to the Observatory tract outside the circle be sold.

ESTIMATES.

In the department of astronomical observations there are large arrears of work on observations made, some of them as many as fifty years ago. The reduction of these observations should be completed and the work of the Observatory brought up to date. With the present force of computers it is practically impossible to do this. An increase in the number of assistants in this department or an increase in the appropriation for miscellaneous computations is urgently needed.

It is further recommended by the Superintendent that the titles of the employees now called "computers, assistant on the equatorial, and assistant in spectroscopic work," be changed to "assistants in making and reducing astronomical observations," and that one assistant at $1,600 and two at $1,400, in place of two computers at $1,200, be allowed

nces (*specification No. 25 of M*
June 11, 1906.

eater than 25 omitted.

	Chronometer room. (Orientation			
.38	**72.14**	**74.76**	**73.72**	**73.74**
6	**46**	**49**	**46**	**53**
r. 24 to r. 31.	Apr. 2 to Apr. 9.	Apr. 9 to Apr. 16.	Apr. 16 to Apr. 23.	Apr. 23 to Apr. 30.
s.	*s.*	*s.*	*s.*	*s.*
2.17	+0.49	+0.51	+0.40	+0.24
1.20	+0.44	+0.19	+0.06	+0.24
0.76	−1.26	−1.53	−1.54	−1.47
2.11	+0.31	+0.20	+0.01	+0.01
1.09	−0.54	−0.61	−0.77	−0.86
2.13	+0.79	+0.77	+0.70	+0.77
1.83	+0.86	+0.96	+0.68	....
2.89	+1.90	+1.80	+1.61	+1.49
0.17	+0.07	−0.01	−0.11	−0.17
0.29	+0.46	+0.13	+0.20	−0.20
0.46	−0.16	−0.29	−0.43	−0.61
0.01	−1.21	−1.43	−1.87	−2.04
1.17	+1.03	+1.00	+1.06	+0.87
1.76	+0.73	+0.63	+0.51	+0.36
1.91	−0.03	−0.40	−0.59	−0.79
2.31	+1.10	+0.99	+0.73	+0.56
0.60	+0.33	+0.24	+0.23	+0.1
0.51	−0.06	−0.51	−0.51	−0.64
1.61	−0.51	−0.51	−0.99	−1.29
0.24	−0.71	−0.90	−1.21	....
0.21	−1.11	−1.31	−2.10	−2.24
1.11	−1.17	−1.44	−1.56	−1.7
0.36	−1.13	−1.49	−1.64	....
0.91	+0.33	+0.43	+0.13	−0.27
2.93	+1.50	+1.37	+1.16	+0.9
0.34	−1.36	−1.66	−1.95	....
0.19	+0.47	+0.24	+0.14	−0.1

1

g
T
b
fe
2

a
e
o
fe
al

st
ti
b

in
o

o
a
w
o
th
a

th
as
a
$1
al

Unite

n 25 or

Chron
2.14
46
pr. 2 *to* pr. 9.
s. −1.98 −0.42 +0.96 −1.42 −0.70 −2.82 −3.28 +1.46 −4.84 −4.74 −2.74 +0.48 −4.84 +1.78 −1.80 +3.90 +2.68

United States Naval Obs

n 25 omitted.

Chronometer room. (Orientation c

2.14	74.76	73.72	73.74
46	**49**	**46**	**53**
pr. 2 to pr. 9.	Apr. 9 to Apr. 16.	Apr. 16 to Apr. 23.	Apr. 23 to Apr. 30.
s.	*s.*	*s.*	*s.*
−1.98	−1.84	−1.67	−1.86
−0.42	−0.37	−0.43	−0.54
+0.96	+1.23	+1.33	+1.04
+1.42	+1.47	+1.41	+1.33
−0.70	−0.81	−0.66	−0.73
−2.82	−2.76	−2.60	−2.94
−3.28	−3.26	−3.07	−3.06
+1.46	+2.11	+1.76	+1.66
−4.84	−4.84	−4.60	−4.73
−4.74	−4.76	−4.54	−4.73
−2.74	−3.01	−2.89	−2.90
+0.48	+0.43	+0.11	+0.29
−4.84	−5.14	−5.59	−5.36
+1.78	+1.47	+1.54	+1.61
−1.80	−1.23	−1.39	−1.19
+3.90	+4.00	+3.83	+3.77
+2.68	+3.03	+3.23	+3.63

tory

er gre

ged.)

90

Ma

Ma

tory, Washington, D. C., Januar

er greater than 25 omitted.

ged.)	Chronometer room. (Orientatio			
90.88	72.14	74.76	78.72	78.74
56	46	49	46	53
Mar. 24 to Mar. 31.	Apr. 2 to Apr. 9.	Apr. 9 to Apr. 16.	Apr. 16 to Apr. 23.	Apr. 2 to Apr. 3
s.	s.	s.	s.	s.
+0.93	−0.33	−0.41	−0.33	....
+3.27	+2.91	+3.00	+3.03	+2.
−0.20	−0.01	−0.20	−0.29	−0.
−0.37	−0.77	−0.99	−0.84	−1.
+2.73	+1.83	+1.87	+1.84	+1.
+1.53	+0.73	+0.66	+0.66	+0.
+0.04	−0.57	−0.79	−0.96	−1.
+1.13	+0.53	+0.54	+0.57	+0.
+0.04	+1.26	+1.10	+1.00	+0.
+0.87	−0.67	−0.96	−1.11	−1.
+1.44	+0.63	+0.27	+0.19	+0.
−1.00	−0.66	−0.97	−1.04	−1.
+0.53	−0.36	−0.49	−0.59	−0.
+1.20	0.00	+0.04	+0.23	−0.
−0.47	+0.43	+0.31	+0.39	−0.
+0.99	+0.01	−0.10	−0.16	−0.
+0.77	+0.81	+0.43	+0.09	+0.
+2.39	+2.23	+1.99	+1.93	+1.
−0.94	−0.61	−1.09	−1.23	−1.
−0.41	+0.16	−0.20	−0.24	−0.
−2.14	−1.37	−1.73	−2.03	−2.
+3.96	+3.33	+3.23	+3.13	+3.
+0.30	−0.87	−0.44	−0.61	−0.
−1.81	−3.27	−3.16	−3.33	−3.
+0.11	−0.56	−0.46	−0.67	−0.
+0.63	−0.24	−0.27	−0.27	−0.
+2.91	+0.54	+0.66	+0.50	+0.
+1.61	−0.11	−0.11	−0.14	−0.
−2 87	−3.90	−4.01	−4.17	−4.
+0.34	−0.69	−0.84	−0.99	−1.
+0.84	+0.26	+0.27	+0.07	−0.
−0.14	−0.50	−0.74	−0.91	−1.
+2.50	+2.70	+2.36	+2.49	+2.
+2.94	+2.03	+2.07	+2.11	+1.
+3.23	+2.24	+1.97	+1.97	+1.
−1.53	−1.66	−1.66	−1.51	−1.
−0.96	−1.84	−1.86	−2.06	−2.
+2.31	+0.24	+0.20	−0.01	−0.
+1.01	−1.33	−1.39	−1.61	−1.
+0.81	−0.89	−0.96	−0.94	−0.

IE

NAVY DEPARTMENT
UNITED STATES NAVAL OBSERVATORY

SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30

1907

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

SYNOPSIS OF THE REPORT

OF THE

SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1907.

Rear-Admiral Asa Walker, U. S. Navy, was Superintendent of the Naval Observatory throughout the year.

DEPARTMENT OF NAUTICAL INSTRUMENTS AND GENERAL STOREKEEPER.

This department was in charge of Commander T. D. Griffin, U. S. Navy.

The number of shipments made during the year was 558, amounting in value to $115,954.22. The value of the instruments received was, by purchase, $47,417.39, and by return from navy-yards, etc., $77,883.91. The value of the stock on hand is $100,000.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department was in charge of Commander E. E. Hayden, U. S. Navy.

The regular annual chronometer trial began December 31, 1906, and ended June 3, 1907. The total number of instruments under trial, only slightly less than last year, was as follows: Thirty-three new chronometers, 35 new torpedo-boat watches, and 100 old naval chronometers.

The accompanying tabular statements, Tables I, II, and III, give all the data and results of the trial for those instruments that were received in time and that obtained a trial number of 25 or less.

The regular work of the department in connection with the rating and issue of chronometers, the testing of new chronometers, watches, and clocks, and the sending out of the daily telegraphic time signals has been heavier than usual during the year, as shown by the following brief summary, which of course does not include any account of the voluminous records and correspondence therewith:

Number of chronometers received	262
Number of chronometers sent out	255
Number of watches received	272
Number of watches sent out	248
Number of clocks received	194
Number of clocks sent out	194

The mean daily error of the noon signal for the year was $0^s.073$, the maximum error on any day being $0^s.56$.

The attention of the Department is invited to the need of an additional officer in this department and one also in that of nautical instruments.

COMPASS OFFICE.

This office was in charge of Lieut. Commander J. M. Ellicott, U. S. Navy, from July 1, 1906, to August 10, 1906, and in charge of Commander Thomas Snowden, U. S. Navy, from August 10, 1906, to June 30, 1907.

The superintendent of compasses points out the desirability of the assignment of a competent officer as an assistant and also the need of a clerk in the office.

The supply of compass material in stock is barely sufficient to meet current demands, and it is recommended that a slightly greater margin of supplies be kept on hand in order to be prepared for emergencies.

The recommendation of last year that a special building be provided for the mounting of the experimental machine Scoresby, so that students may utilize the sun in compass work, is renewed.

This office tests all compasses before delivery, takes magnetic observations on all new ships to determine the fitness of their compass stations, and to obtain information to be used in locating compasses in future ships and for data for instruction of officers taking the course of instruction offered by the office. During the year 14 officers have taken this course.

NAUTICAL ALMANAC OFFICE.

This office has continued under the direction of Professor of Mathematics W. S. Harshman, U. S. Navy.

There have been received during the year from the Government Printing Office 700 copies of the American Ephemeris and Nautical Almanac for 1907, second edition; 2,900 copies of the American Nautical Almanac for 1907, second edition; 200 copies of the American Ephemeris and Nautical Almanac for 1907, third edition; 1,000 copies of the American Ephemeris and Nautical Almanac for 1909, first edition; 500 copies of the American Nautical Almanac for 1909, first edition; 1,000 copies of the American Ephemeris and Nautical Almanac for 1910, first edition; and 500 copies of the American Nautical Almanac for 1910, first edition.

During the present fiscal year the sale and distribution of publications were as follows:

Title.	Sold.	Public service and exchanges.	Total.
American Ephemeris and Nautical Almanac	79	1,081	1,160
American Nautical Almanac	784	242	1,026
Pacific Coaster's Nautical Almanac	74	1	75
Astronomical papers	5	90	95

The proceeds of sales, amounting to $328.58, have been deposited with the Treasurer of the United States to the credit of public printing.

The distribution of miscellaneous publications, Astronomical Constants, Zodiacal Catalogue, Star Tables, Tables of the Moon, etc., has continued through the year.

By direction of the Secretary of the Navy the sale of publications of the Nautical Almanac Office was transferred to the superintendent of documents, Government Printing Office, October 1, 1906. Since that date the superintendent of documents has been supplied by the Navy Department with the following publications for sale:

	Copies.
American Ephemeris and Nautical Almanac	1, 150
American Nautical Almanac	3, 094
Atlantic Coaster's Nautical Almanac	90
Pacific Coaster's Nautical Almanac	227
Astronomical Papers	870

The current work of the office is up to date. The ephemeris of the sixth satellite of Jupiter is now given for the first time in the American Ephemeris, and the reductions are being made preparatory to publishing the ephemeris of the seventh satellite of Jupiter.

THE DIVISION OF EQUATORIAL INSTRUMENTS.

This division has continued in charge of Professor of Mathematics A. N. Skinner, U. S. Navy.

The following observations have been made during the year:

Satellites of Mars	8
Satellites of Saturn	111
Satellites of Uranus	30
8 comets	57
58 asteroids	238
Double stars	10
Comparison stars	4
Miscellaneous stars	54
Occultations of stars by Moon	9
Total observations	521

It is the aim of the division of equatorial instruments to make measurements of the positions of comets, asteroids, and the satellites of the planets, and to observe as far as is practicable the occultations of stars by the moon which are predicted in the American Ephemeris. Determinations of the orbits of several comets and asteroids have been made during the year.

The number of visitors received by permit for a view of the heavens through the 12-inch equatorial has been 1,065.

THE DIVISION OF MERIDIAN INSTRUMENTS.

This division has continued in charge of Professor of Mathematics W. S. Eichelberger, U. S. Navy.

The 9-inch transit circle.—The plan of work decided upon for this instrument in the fall of 1903 has been continued during the year just ended. The work of obtaining four observations of each star in Sir David Gill's Zodiacal Catalogue of 2,798 stars was completed in October, 1906, with the exception of a few stars which need one more observation each. These stars are so scattered in right ascension that it will take until the autumn of 1907 to obtain the desired observations.

The number of observations from July 1, 1906, to June 30, 1907, is as follows:

Zodiacal stars	1,175
Standard stars	1,709
Miscellaneous stars	22
Screen stars for personal equation	150
Zenith stars for personal equation	232
Sun	63
Moon	46
Mercury	27
Venus	52
Mars	6
Saturn	11
Uranus	6
Total	3,499

The determination of the division errors of the circle graduations has been continued. The corrections for all the degree and half-degree divisions and one-third of the remaining ones have been determined.

In order to better protect the instrument from the sun's rays during the observation of the sun, a new sunshade 4 feet wide and 43 feet long containing an 8-inch circular hole has been mounted to run on curved tracks, one on each side of and parallel to the meridian of the instrument. When not in use this shade is wound around a drum situated between the south collimator pier and the south wall. By means of this shade both collimators and their piers, together with the transit circle and its piers, are protected from the direct rays of the sun at apparent noon. Only the object-glass of the transit circle receives the sunlight.

The erection of this shade and a determination of the pivot errors of the transit circle prevented for several months the use of the instrument for observing.

The apparent right ascension and declination of the observations to April, 1907, have been obtained, with the exception of the application of the clock corrections, flexure corrections, corrections for division error and those for variation of latitude. The reductions to mean place are computed to March, 1905.

The 6-inch transit circle.—In October, 1906, the new self-registering transit micrometer, made for this instrument by the Warner & Swasey Company, was brought into use, and since then something over 3,000 star transits have been observed by five different observers. A discussion of these observations confirms the results obtained by other observers, that the relative personal equation of different observers is of the same order as its probable error. The relative personal equation of two of the five observers as determined by the key method of observing is $0^s.20$.

Clock vault.—During August, 1906, the roof of the old magnetic vault caved in, and in making repairs it was decided to utilize this old vault, which has not been in use for nearly ten years, for a clock vault. The old piers for the magnetic instruments have been removed, clock piers have been built, a new concrete roof 10 inches thick and covered with 2 feet of earth has been constructed, and a hot-water heating plant installed.

Astronomische Gesellschaft Zone Catalogue −13° 50′ to −18° 10′.—The work on this catalogue is finished and the printer's copy completed except for a discussion of the proper motions in which Professor Skinner is now engaged. In this work catalogues in addition to the four mentioned in previous reports will be used whenever possible.

Washington Zone Catalogue.—The zone corrections have been applied to all the published results obtained with the mural circle and the transit instrument, and the comparison with the Cordoba General Catalogue for a determination of the zone corrections is about one-third completed for the meridian circle zones.

Printing.—During the past year Volume IV, Publications of the United States Naval Observatory, Second Series, mentioned in the last annual report as in press, has been distributed.

DIVISION OF THE ALT-AZIMUTH INSTRUMENT.

This division has continued in charge of Professor of Mathematics F. B. Littell, U. S. Navy.

The instrument has been used as a vertical circle for determining the declinations of the stars of Newcomb's Suggested List of Fundamental Stars which culminate here at zenith distances less than 75°. The observing list comprises 1,186 stars for upper culmination and 136 stars for lower culmination. The number of observations obtained during the year was 1,489.

The reductions are in a satisfactory state of progress.

The divisions of the circle having become badly worn by repeated cleanings, it is proposed to have the circle regraduated in the near future, and it is hoped that a way will be found of avoiding the troubles hitherto experienced from the tarnishing of the silver graduated strip and from rust gathering at the junction of the silver strip with the steel circle.

Plans and specifications for a new house, with movable roof, have been made and an appropriation secured for it from Congress, and it will be erected during the present fiscal year.

DIVISION OF THE PRIME VERTICAL INSTRUMENT.

This division has continued in charge of Assistant Astronomer G. A. Hill.

The same method has been used in observing with the instrument as has been outlined in former reports. The transit is in good working order, as well as the apparatus connected therewith. There were made with it during the past year 429 observations.

The observations secured with the instrument are reduced, checked, and copied on the printer's form up to January 1, 1907. The observations awaiting publication now amount to 4,953, would make a volume of 620 pages, and, including about 100 additional pages for the introduction, one of the size usually issued by the Observatory.

The observer is now engaged in discussing the observations secured by the polygon method in the years 1904, 1905, and 1906, for the purpose of obtaining a value of the Constant of Aberration therefrom.

THE PHOTOHELIOGRAPH.

This instrument has continued in charge of Assistant G. H. Peters.

The sun has been photographed with the photoheliograph on one hundred and fifty days, and solar spots were observed on these plates on one hundred and forty-eight days. This is a slight decrease from the number obtained during the previous fiscal year and is due to the great amount of cloudiness prevailing during the period covered by this report.

Two enormous groups of solar spots were observed during this period, one in February and the other in June. The former group was one of the largest ever noted, and both were announced from here and received much attention from the press.

The total number of solar negatives now on hand is 1,455, and it seems desirable to measure and reduce them. The process of measuring the coordinates of the spots on a dividing engine and their subsequent reduction involves an immense amount of labor. It is suggested that a heliomicrometer as devised by Professor Hale be installed. The plates can then be accurately measured and an enormous amount of computing avoided, thus economizing time and hastening results. The record of the spots at present gives only approximate positions, which are not available for scientific discussion, being tabulated merely for reference.

THE LIBRARY.

The library has continued in charge of the librarian, W. D. Horigan.

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1906	20,445	4,276	24,721
Accessions	467	93	560
Contents July 1, 1907	20,912	4,369	25,281

Of the accessions, 331 were received as exchanges and 229 were purchased.

There were distributed 2,569 copies of the various publications of the Observatory.

The routine work of the library is up to date.

PUBLICATIONS.

During the fiscal year ending June 30, 1907, Volume IV has been issued.

As showing the contributions to astronomy in general in other than Government publications, the following list of articles made public is submitted:

In the Proceedings of the Seventh Session of the International Railway Congress Association: "A telegraphic time signal in honor of the International Railway Congress," by E. E. Hayden.

In Science of March 22, 1907: "Clocks—Ancient and modern," address of the retiring vice-president of Section A, American Association for the Advancement of Science, by W. S. Eichelberger.

In Science of June 28, 1907: "The clock of the U. S. Naval Observatory," by W. S. Eichelberger.

In the Astronomical Journal, No. 587: "A comparison of two methods of obtaining level corrections in prime vertical transit observations," by Geo. A. Hill.

In the Astronomische Nachrichten, Nr. 4102: "Provisional elements and ephemeris of 1906 U J," by J. C. Hammond and Matt Frederickson.

In the Astronomische Nachrichten, Nr. 4129: "Provisional elements of (600) [1906 U M]," by J. C. Hammond and Matt Frederickson.

In the Astronomische Nachrichten, Nr. 4139: "Elements and ephemeris of comet 1906 *h*," by Eleanor A. Lamson.

In the Astronomische Nachrichten, Nr. 4156: "Provisional elements of planet 1906 V L," by J. C. Hammond. "Finding ephemeris for (581) Tauntonia," by Herbert R. Morgan.

In the Astronomische Nachrichten, Nr. 4157: "Elements of the minor planet 1906 W O = (260) Huberta," by Matt Frederickson.

In the Astronomische Nachrichten, Nr. 4172: Elements and ephemeris of comet 1907 *b*," by Eleanor A. Lamson and C. W. Frederick.

In the Astronomische Nachrichten, Nr. 4173: "Elements of comet 1907 *a*," by Eleanor A. Lamson.

In the Astronomische Nachrichten, Nr. 4183: "Provisional elements of 1906 W P," by J. C. Hammond. "Elements of (245) Vera," by Eleanor A. Lamson.

In Popular Astronomy for October, 1906: "The effect of temperature upon the constants of a transit circle," by Herbert R. Morgan.

Also numerous observations of satellites, asteroids, and comets.

A lecture on "The sun and solar eclipses" was given before the Pi Beta Phi Sorority of the George Washington University on March 6, 1907, by Geo. H. Peters.

BUILDINGS, GROUNDS, AND ROADS.

The buildings are in good condition. All of those containing instruments were painted last fall and minor repairs made.

Accommodations for the observers have been improved, adding much to their comfort.

A 125-horsepower boiler has been installed for heating, and all the clock circuits have been rewired with lead-incased wires.

The roads have been kept in repair. About 100 yards of concrete pavement has been laid. A large fill was made in the northeast portion of the circle and the grade brought up to that of Massachusetts avenue; but when repairs were made on the avenue its grade was raised, in places 4 feet, thus necessitating a still further fill in the Observatory grounds.

Nothing has been done with reference to the acquisition of the grounds of the Industrial Home School and the Normanstone tract, which lie within the defined boundary of the Observatory. This latter tract has been before the court for condemnation for three years, but the case has not been pushed. It is recommended that title be acquired to both of these tracts.

It is recommended that none of the land belonging to the Observatory tract outside of the circle be sold.

ESTIMATES.

It has been found impossible to obtain a sufficient force of computers from the civil service, so that, with a great amount of work waiting to be done, a part of the appropriation for miscellaneous computing has been covered into the Treasury. The rates of pay for the present assistants at the Observatory were established in 1891. Since that date there has been change in but one salary, a raise of $200. It is earnestly recommended that the pay be increased. It is probable that with the incentive of promotion with better pay we might be able to retain the services of the employees in these positions. At present hardly does an assistant get thoroughly familiar with his duties before he resigns to take some office paying a higher salary.

tion No. 16 C 1, of August 25, 1906), United States Naval

ed.

r room. (Orientation changed for polarity test, one week on E., W., S., and N.)

27	70.48	69.49	71.56	69.48	68.92	69.82	67.88	68.71
9	44	51	54	64	58	64	66	65
. 1 . 8.	Apr. 8 to Apr. 15.	Apr. 15 to Apr. 22.	Apr. 22 to Apr. 29.	Apr. 29 to May 6.	May 6 to May 13.	May 13 to May 20.	May 20 to May 27.	May 27 to June 3.
.	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*
. 27	+0.24	+0.20	+0.17	+0.23	+0.30	+0.36	+0.31	+0.24
1.16	+1.23	+1.04	+1.37	+0.94	+0.97	+1.07	+1.13	+1.19
0.54	−0.87	−1.04	−0.94	−0.80	−0.93	−0.79	−0.73	−0.84
0.86	−0.93	−1.07	−0.84	−0.81	−0.61	−0.53	−0.37	−0.41
0.57	−0.64	−0.60	−0.81	−0.70	−0.69	−0.71	−0.71	−0.79
1.73	−1.94	−1.80	−1.91	−1.97	−2.17	−2.27	−2.46	−2.50
0.57	−0.73	−0.76	−0.91	−0.61	−0.66	−0.74	−0.83	−0.80
1.96	−2.16	−2.17	−2.33	−2.40	−2.59	−2.64	−2.57	−2.64
0.50	−0.29	+0.66	−0.20	+0.49	+0.16	+0.11	+0.23	+0.37
0.77	−0.96	−0.77	−0.81	−0.93	−1.14	−1.13	−1.31	−1.33
1.26	−1.43	−1.17	−1.29	−1.27	−1.46	−1.57	−1.50	−1.29
0.63	−0.54	−0.61	−0.74	−0.70	−0.84	−0.81	−0.66	−0.39
2.31	−2.47	−2.36	−2.53	−2.76	−2.69	−2.74	−2.56	−2.49
0.83	+0.44	+0.51	+0.33	+0.30	+0.39	+0.29	+0.53	+0.26
1.31	−1.53	−1.00	−0.89	−1.09	−0.87	−0.69	−0.47	−0.80
0.03	−0.23	−0.17	−0.17	−0.16	−0.24	−0.27	−0.19	−0.09
2.81	−2.89	−3.14	−3.30	−3.76	−3.70	−3.53	−3.40	−3.63
0.11	−0.27	−0.23	−0.43	−0.11	−0.24	−0.39	−0.41	−0.34
0.73	−1.09	−0.90	−1.03	−1.07	−1.36	−1.40	−1.13	−1.07
0.64	+0.37	+0.37	+0.16	+0.14	+0.03	−0.19	0.00	+0.19
1.23	−1.56	−1.57	−1.84	−1.76	−1.87	−1.93	−1.54	−1.61
0.70	+0.36	+0.47	+0.14	+0.19	+0.01	−0.33	−0.01	+0.21

States

ed.

er room.	
27	7
9	
r. 1 . 8.	A Ap
. 46 . 96 . 74 . 79 . 43 . 57 . 44 . 09 . 30 . 03 . 34	

States Naval Observatory, Washington, D. C., January 0 to

ed.

r room. (Orientation changed for polarity test, one week on E., W., S., and N.)

.27	70.48	69.49	71.56	69.48	68.92	69.82	67.88	68.71
9	44	51	54	64	58	64	66	65
r. 1 . 8.	Apr. 8 to Apr. 15.	Apr. 15 to Apr. 22.	Apr. 22 to Apr. 29.	Apr. 29 to May 6.	May 6 to May 13.	May 13 to May 20.	May 20 to May 27.	May 27 to June 3.
	s.	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*
. 46	−3. 41	−3. 19	−3. 27	−3. 20	−3. 23	−3. 06	−3. 03	−3. 07
1. 96	−2. 06	−1. 89	−2. 03	−1. 79	−1. 90	−2. 07	−2. 07	−2. 01
1. 74	−1. 67	−1. 44	−1. 31	−1. 50	−1. 36	−1. 23	−1. 26	−1. 17
. 79	−0. 67	−1. 30	−1. 11	−0. 71	−0. 90	−1. 04	−1. 03	−1. 30
. 43	−0. 36	−0. 27	−0. 29	−0. 11	−0. 10	−0. 17	+0. 03	+0. 16
. 57	−0. 59	−0. 17	−0. 21	−0. 19	−0. 36	−0. 11	−0. 23	+0. 07
2. 44	−2. 70	−2. 90	−2. 87	−2. 80	−2. 66	−2. 57	−2. 39	−2. 46
3. 09	+3. 20	+3. 11	+3. 16	+3. 41	+3. 44	+3. 50	+3. 47	+3. 33
. 30	+0. 17	+0. 16	+0. 44	+0. 44	+0. 39	+0. 23	+0. 26	+0. 41
1. 03	−1. 09	−0. 59	−1. 03	−0. 87	−0. 99	−1. 20	−1. 10	−1. 24
. 34	+0. 36	+0. 34	+0. 27	+0. 26	+0. 60	+0. 14	−0. 13	−0. 27

D. C.,

r room.	(
7	70.
	44
1 8.	Apr to Apr.
	s.
06	+1
29	−
84	+
27	+1
43	+
61	+
11	+
84	+
10	+
50	−
04	+
57	−
19	−
17	+
30	−
30	+
31	−
21	
40	−
06	−
46	−
57	−
53	−
59	−
16	−
63	−
89	−
93	−
69	
60	
30	
57	
71	
11	
37	
40	
31	
57	
56	

D. C., January 0 to June 3, 1907.

r room. (Orientation changed for polarity test, one week on E., W., S., and N.)

7	**70.48**	**69.49**	**71.56**	**69.48**	**68.92**	**69.82**	**67.38**	
	44	**51**	**54**	**64**	**58**	**64**	**66**	
1 8.	Apr. 8 to Apr. 15.	Apr. 15 to Apr. 22.	Apr. 22 to Apr. 29.	Apr. 29 to May 6.	May 6 to May 13	May 13 to May 20.	May 20 to May 27.	Last week omitted.
	s.	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	
06	+1.91	+2.09	+1.87	+2.09	+1.94	+1.91	+2.20	....
29	−0.36	−0.33	−0.47	−0.60	−0.50	−0.51	−0.41	....
84	+0.74	Issued to the Kearsarge.						
27	+1.23	+1.29	+1.13	Issued to the Missouri.				
43	+0.40	Issued to the St. Louis.						
61	+1.69	+1.84	+1.70	+1.91	+1.86	+1.81	To Olympia.	
11	+0.03	+0.01	−0.09	Issued to the Sterling.				
84	+2.69	+2.70	+2.83	+2.74	+2.93	Issued for observatory use.		
10	+1.19	+1.26	+1.24	Issued to the Abarenda.				
50	−0.39	−0.46	−0.97	Issued to the Iowa.				
04	+0.83	Issued to the Alabama.						
57	−0.93	−0.51	−0.89	−0.66	−0.91	−0.80	−0.94	....
19	−0.21	−0.19	−0.27	−0.30	−0.30	−0.33	−0.24	....
17	+1.14	+1.11	+1.11	Issued to the Ohio.				
		Issued to branch hydrographic office, Galveston.						
30	−0.61	−0.34	−0.46	Issued to the Worden.				
30	+0.21	+0.10	−0.13	Issued to the Marcellus.				
		Issued to the Cleveland.						
		Issued to the Brooklyn.						
		Issued to the Denver.						
31	−1.46	−1.31	−1.34	−1.40	−1.49	−1.60	−1.59	....
		Issued to the Lebanon.						
21	0.00	Issued to the Alabama.						
		Issued to the Denver.						
40	+0.23	Issued to the St. Louis.						
06	−1.13	−1.14	−1.24	−1.10	−1.21	−1.26	−1.23	....
46	+0.50	+0.77	+0.90	+0.67	+0.56	+0.69	+0.67	....
57	−0.70	−0.73	−0.77	−0.63	−0.80	−0.71	−0.64	....
53	+1.44	+1.37	+1.39	+1.36	+1.24	+1.29	+1.10	....
59	+0.60	+0.43	+0.37	+0.49	+0.33	+0.37	+0.31	....
		Issued to the Stewart.						
16	+1.03	+0.99	+1.04	+1.03	+1.06	+1.06	+1.09	....
63	+1.44	+1.63	+1.53	Issued to the Sterling.				
89	−1.94	−1.90	−1.81	Issued to the Hopkins.				
93	−1.96	−1.96	−1.87	−1.87	−1.87	−1.87	−1.96	....
		Issued to the Cleveland.						
		Issued to the Minnesota.						
69	+0.61	+0.60	+0.59	+0.40	+0.31	+0.53	+0.37	....
60	−0.67	−0.50	−0.60	−0.31	−0.21	−0.11	+0.06	....
30	+0.17	+0.23	+0.01	+0.41	+0.47	+0.34	+0.54	....
57	−2.66	−2.07	−2.51	Issued to the Hannibal.				
		Issued to branch hydrographic office, Philadelphia.						
71	−0.97	−0.63	−0.89	−0.79	−1.00	−1.00	−0.73	....
11	−1.26	−1.33	−1.16	−1.27	−1.37	−1.37	To the Brutus.	
37	+0.17	+0.10	−0.14	−0.30	−0.30	−0.41	−0.39	....
40	+0.37	+0.53	+0.40	+0.59	+0.27	+0.19	+0.19	....
31	+1.99	+1.83	+1.66	Issued to the Glacier.				
57	−0.73	−0.77	−1.06	−1.17	−1.39	−1.37	−1.46	....
		Issued to Fort Monroe, Time Signal Station.						
.56	−0.61	−0.61	−0.67	−0.71	−0.84	−0.80	To the Alliance	
		Issued to the Rhode Island.						

UNIV. OF MICH.

NAVY DEPARTMENT
UNITED STATES NAVAL OBSERVATORY

SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30

1908

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

SYNOPSIS OF THE REPORT
OF THE
SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY
FOR THE
FISCAL YEAR ENDING JUNE 30, 1908.

Rear-Admiral Asa Walker, U. S. Navy, was Superintendent until his retirement, November 13, 1907. Capt. W. J. Barnette, U. S. Navy, assumed the duties of Superintendent on December 2, 1907.

Feeling the need of more detailed information regarding the work of the Department of Astronomical Observations, the following order was issued organizing a board to report on the various subjects therein mentioned:

U. S. Naval Observatory,
Washington, D. C., May 9, 1908.

Gentlemen: The recent written suggestions of the staff of the observatory regarding the future plan and scope of work indicate an unanimity of opinion that the chief efforts of the observatory should be in the direction of fundamental meridian work of the highest possible order, first to furnish the data necessary for the computations of the American Ephemeris, and secondly, to meet the requirements of astronomers in this particular branch of their work. Several eminent astronomers concur in this opinion.

Giving due weight to the above opinions and having in view the best interests of the observatory, I desire that the officers named below, acting as a board, shall consider the above written suggestions of the staff of the observatory, consult such persons and papers as may be necessary, and, as soon as practicable, shall advise me on the following subjects pertaining to the Department of Astronomical Observations:

(*a*) A general plan of work for the various instruments to cover a period of years.

(*b*) The number of observers required to employ all instruments to the best advantage, and the number of computers necessary to properly balance the force of observers. The apportionment of the work of reducing the observations between the observers and computers in such a way as to expeditiously prepare the observations for publication.

(*c*) The condition of all instruments and their availability for immediate use. If not available, in what respect and why. The extent to which instrumental errors have been investigated. The improvements needed to insure the most accurate observations.

(*d*) The status of work in connection with observations; their astronomical value and the sequence in which their reduction and publication should be undertaken.

(*e*) Any other subjects necessary to the efficiency of the astronomical work.

Very respectfully,

W. J. Barnette,
Captain, U. S. Navy, Superintendent Naval Observatory.

Members of the board.—Commander A. G. Winterhalter, U. S. Navy, senior member; Professor of Mathematics Milton Updegraff, U. S. Navy, member; Professor of Mathematics W. S. Eichelberger, U. S. Navy, member; Professor of Mathematics F. B. Littell, U. S. Navy, member; Professor of Mathematics Asaph Hall, U. S. Navy, member.

The board began its work on May 11 and submitted its report on July 8.

Commander Winterhalter having been detailed as Hydrographer of the Navy, was detached from the observatory and Assistant Astronomer George A. Hill was made a member of the board to fill the vacancy.

The following are some of the more important conclusions and recommendations of the board and are approved by the Superintendent.

PLAN OF WORK.

The astronomical work of the Naval Observatory should be so planned and executed as to best subserve the two following purposes, to wit:

(*a*) To furnish to the Nautical Almanac Office, as far as may be possible, such observations and such data as may be needed for carrying out the purpose of the law under which the appropriations for that office are made from year to year, which is as follows: "For * * * preparing for publication the American Ephemeris and Nautical Almanac and improving the tables of the planets, moon, and stars * * *."

(*b*) To make such other observations for the promotion of astronomical science and geodesy and of navigation as may properly fall within the province of a great astronomical observatory maintained at government expense.

The principal work of this observatory should be in the field of the astronomy of position as distinguished from the astrophysical work which has attained in recent years such great development in the world and which is being so efficiently and so extensively carried on elsewhere in this country.

The instruments and methods used here and the selection and training of observers should be continuously and constructively adapted to the highest efficiency in the astronomy of position. In doing this, advantage should be taken of progress made in such work in this country and abroad. The methods should be adjusted to the present state of astronomy and to local conditions and should be, as far as possible, independent and original rather than imitative.

The so-called fixed stars being a system of points to which all other heavenly bodies are referred, the determination with the highest accuracy possible of the positions of these objects is of the utmost importance in astronomy. Since the fixed stars are subject to proper motion, the places of those which are used for the above purpose must be predicted with great accuracy for many years in advance. The so-called fundamental or standard stars are those whose past and present places are well enough known so that this can now be done. But unless the observation of these stars is continued, their predicted places will decrease in accuracy from year to year. Indeed, the places of few of them are as well determined as they should be even now, and besides the number of fundamental stars, ephemerides of whose apparent places are printed in the American Ephemeris from year to year should be increased, especially in certain parts of the sky.

Therefore the main feature of a plan of work for this observatory should be the establishment and continued maintenance of meridian observations for absolute positions of the fundamental stars and of stars which are to be made fundamental, and in addition the independent determination by observations of the sun, of the position of the equator and equinox among the stars. The values of the constants of nutation and aberration on which all these operations depend should also be independently determined. Then determinations of the positions of the moon and planets with reference to the fundamental stars present few difficulties.

GENERAL PRINCIPLES GOVERNING FUNDAMENTAL WORK.

Determinations of positions of the heavenly bodies with reference to the equator and equinox, made in such a way as to be independent of other similar work, are to be regarded as fundamental or absolute in distinction from determinations of position merely with reference to the so-called fundamental or standard stars, which must be regarded as differential or relative.

In the execution of fundamental work, the observations should be so planned and so made as to give when reduced, as directly as possible, positions in both right ascension and declination of a fundamental or absolute character. Such observations may, if desired, be reduced in such a way as to give also differential results, but it is not advisable to make differential observations with a view to deducing therefrom fundamental results. Instrumental errors and errors in the adopted values of the constants of nutation and aberration as well as the variations of latitude and azimuth due to variability in the motion of the zenith point among the stars should be eliminated as far as possible in the processes of observation and reduction rather than by the application of numerical corrections.

Absolute determinations of declination must be made with reference to the equator point or to the polar point of the divided circle, and these points must be found by observations of the same circumpolar stars at both upper and lower culmination. The upper and lower culminations of any one circumpolar star observed should be as far as possible consecutive—that is, twelve hours apart. Since, in practice, the zero point, or rather the index of a divided circle, does not remain fixed for any considerable length of time, and because the observations of a circumpolar star at upper and lower culmination are at least twelve hours apart, some fixed point which can be observed directly, as the nadir point or the horizontal point, must be observed at the time of both upper and lower culmination. The mean of the two altitudes of the star derived from these observations may, when corrected for refraction, be regarded as a fundamental or absolute determination of the latitude of the place of observation. The latitude, when combined with the circle reading on either the nadir point or the horizontal point gives either the polar point or the equator point of the circle.

The difference between the circle reading for the equator point and the circle reading on any star on the meridian, the latter being corrected for refraction, gives a fundamental or absolute determination of the declination of the star. The atmospheric refraction at all zenith distances should be investigated by the best methods and fundamentally determined under conditions the same as those under which the above described observations are made.

The equinoxes and the obliquity of the ecliptic are determined by means of fundamental observations of the declination of the sun. Then the right ascensions of a limited number of so-called fundamental or standard stars are determined by transit and clock observations of their distances in hour angle from the sun. These stars should be within perhaps 15° or 20° of the equator, and bright enough to be observed in the daytime. Then, by means of transit observations with a clock of the best possible rate, the absolute right ascension of any other star or heavenly body may be determined. The clock rate must be determined by means of the same stars observed at consecutive transits. The clock error at any instant must be found from this rate, and from the error at some epoch based upon the known or assumed right ascensions of some or all of the above mentioned limited number of fundamental or standard stars.

In practice, an azimuth mark or mire is necessary for the best results. The azimuth of the mark, and indirectly that of the instrument, must be determined by observations of circumpolar stars at upper and lower culmination, the same stars being observed as far as possible at culminations which are consecutive. The collimation and level of the instrument will be obtained by the usual mechanical methods.

The constants of nutation and aberration should, of course, be independently determined, but so great is the accuracy of the values of these constants now in general use that any change in their adopted values must be regarded as inadvisable for the present. But approximate or provisional values of these constants would suffice for determination of the polar point and clock rate as above specified for the reason that they enter only in a differential manner. That is, the polar point and clock rate thus determined are affected by slight changes only, in the nutation and aberration, which can be accurately allowed for. The above-mentioned variability in the motion of the zenith point also has a slight differential effect on the position of the polar point and on the clock rate as determined, and also upon the azimuth of the mark.

The application of these principles will vary with the character of the work in hand and according to the individual views and practical methods of the observer. If it should appear to be desirable or necessary to modify this general plan for fundamental work, such change should be made only after due consideration and approval by a board which should act in the light of full knowledge both of the views of all the astronomers of this observatory and of the methods and the character of the results produced at the principal observatories of the world where meridian work is carried on.

It is the opinion of the board that Congress should be asked to appropriate for an assistant in the department of chronometers and time service.

In the opinion of the board the need for additional computers and observers is greater than that for additional equipment aside from such improvements in the present instrumental outfit as have been already recommended.

Furthermore, the efficiency of the entire force of the observatory would be materially increased by better accommodations for both lodging and meals on the observatory grounds. Additional quarters for observers are especially necessary. In this connection attention is called to the following quotation from the Report of the Chief of Bureau of Equipment for the year 1892, page 137, which is as true and as pertinent now as it was at that time:

"NOTE.—In order that the work of a large observatory may be properly and economically done, it is absolutely necessary that the observers be within prompt call to their instruments throughout day and night. Very important observations can often be secured from the clearing of the sky for a few hours, or even in some cases for a few minutes, if the observer be within easy call by the watchman. This can only be accomplished, in the isolated situation of the new observatory, by having dwellings upon the grounds for the observers. The Government erects dwellings at all its navy-yards, arsenals, forts, and schools for the officers on duty there. But no service requires such unremitting attention and constant presence at all hours as that of the astronomer, and no observatory can be regarded as economically managed which does not furnish dwellings for all its observers close by their instruments. It is estimated that with the observers living on the grounds of the new observatory not only will two or three times as much work be done as it will be possible to do otherwise, but the quality of this delicate work will be materially improved on account of the observers being in a proper physical condition to begin their labors, instead of with nerves unstrung from hurrying some miles from their homes immediately after meals, or at unreasonable hours of the night."

The value of the work and advice of this board were convincing proof that the astronomical work of the observatory could be more intelligently and uniformly administered with the advice of a body like the board, selected mainly from the astronomical staff of the observatory; therefore, following the general principles embodied in the recommendations of the Chief of Bureau of Equipment and Superintendent in their combined letter dated September 7, 1897, the following order was issued creating a council, believing that it would become an important element in the administrative machinery of the observatory and insure that continuity of policy and effort which is absolutely essential to its efficiency.

No. 1449.]

U. S. NAVAL OBSERVATORY,
Washington, D. C., July 29, 1908.

ORDER.

There is hereby formed an astronomical council composed of the following members: The Superintendent (ex officio), the Assistant Superintendent, such assistants in charge of the astronomical divisions as the Superintendent may designate, and the Director of the Nautical Almanac.

The council should be guided by the fact that the most important astronomical duty of the Government is the publication of a nautical almanac, and as that is intended not only for the use of navigators, but also of astronomers in the most delicate investigations known to their science, it should be kept up to the highest attainable pitch of accuracy. To that end, continuous fundamental meridian observations upon the sun, moon, planets, and stars are absolutely necessary and constitute the astronomical essentials.

The council shall advise the Superintendent on the following subjects:

1. The coordination and cooperation of the work of the Department of Astronomical Observations and of the Nautical Almanac Office.
2. Suggested variations from the plan of astronomical work prescribed by regulations.
3. Methods to be used in the prosecution of the astronomical work.
4. Condition of and changes proposed in instrumental equipment.
5. The assignment of the scientific personnel to give the best possible results. The assignment of computers should be so made as to balance the work of the observers and computers, in order that observations may be expeditiously published.
6. The character and astronomical value of the observations and their publication.
7. Promotions, transfers, and filling of vacancies.
8. The yearly estimates for submission to the Secretary of the Navy.
9. The expenditure of the appropriations for astronomical and scientific purposes.
10. A system by which the cost of any piece of work may be readily available.

Of the above enumerated subjects, those relating to the Nautical Almanac Office shall be considered first by the director of that office, those relating to the Department of Astronomical Observations shall be considered first by an executive committee, and the conclusions of both shall be submitted to the council.

There shall be formed an executive committee of the council, consisting of three heads of divisions of the Department of Astronomical Observations, to be designated by the Superintendent.

The executive committee shall have charge of all editing and printing pertaining to the Department of Astronomical Observations, and in addition shall undertake any other duties which may be assigned to it by the Superintendent or by the council.

The executive committee shall audit the accounts of the observatory arising from the expenditure of appropriations coming under the following subheads: Miscellaneous computations, Department of Astronomical Observations; professional and scientific books; apparatus and instruments and for repairs of same.

The heads of divisions of the Astronomical Department shall submit their monthly reports of progress to the Superintendent and these shall be laid before the council.

The council shall meet monthly, except in August, and at such other times as the Superintendent may direct.

A clerk shall be detailed to act as secretary of the council and of the executive committee, who shall keep minutes of each meeting in a book or other proper file.

Should the Superintendent not act on the advice of the council, he shall give his reasons therefor, and they shall be entered upon the minutes.

W. J. Barnette,
Captain, U. S. Navy, and Superintendent Naval Observatory.

The marked advantages of this new method of conducting the astronomical work of the observatory are already apparent, and if the above outlined plan of work and the council can be made permanent by proper regulations it is clear that the output from the observatory will in time fully meet the requirements of the Nautical Almanac and of astronomers.

As a result of the recommendations of the board, and with the approval of the council, measures have been taken to put the 6-inch transit circle in good working order, and if found suitable it will be employed in the determination of absolute positions of the sun and fixed stars, as recommended by the board.

It is intended, after thorough consideration and discussion by the council, to make other necessary improvements in the astronomical work of the observatory.

Abstracts of the reports of the heads of the various departments of the observatory follow:

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

From July 1 to August 21, 1907, this department was subdivided as shown in the Superintendent's last annual report. The Division of Equatorial Instruments was in charge of Prof. A. N. Skinner, U. S. Navy, until July 10, 1907, when at his own request he was relieved; the Division of Meridian Instruments was in charge of Prof. W. S. Eichelberger, U. S. Navy; the Division of the Alt-Azimuth Instrument was in charge of Prof. F. B. Littell, U. S. Navy; the Division of Prime Vertical Instrument was in charge of Assistant Astronomer G. A. Hill; and the Photographic Equatorial and Photoheliograph were in charge of Assistant George H. Peters.

On August 21, by order of the Superintendent, Prof. W. S. Eichelberger, U. S. Navy, was placed in charge of all observational work, and this arrangement has been continued to the end of the fiscal year.

THE 9-INCH TRANSIT CIRCLE.

Prof. W. S. Eichelberger, U. S. Navy, in charge.

This instrument has been used in the determination of the right ascensions and declinations of the sun, moon, planets, and the stars of Newcomb's Suggested List of Fundamental Stars. In addition, a few miscellaneous stars were observed and such zodiacal stars as were necessary to complete the four observations of each of those in the zodiacal list under observation for the past few years. Several hundred stars were observed for determination of personal equation and instrumental flexure. The instrument was used clamp east until April 23, and thereafter clamp west.

The number of observations from July 1, 1907, to June 30, 1908, is as follows:

Standard stars	6,585
Zodiacal stars	93
Miscellaneous stars	86
Screen stars for personal equation	297
Zenith stars for personal equation	259
Stars for instrumental flexure	84
Sun	169
Moon	155
Mercury	69
Venus	108
Mars	15
Jupiter	16
Saturn	12
Uranus	6
Neptune	15
Total	7,969

There are still needed about 1,000 observations to complete the 10 observations each of the stars in Newcomb's Suggested List of Fundamental Stars, but these observations are so scattered in right ascension that it will require about ten months to secure them.

In addition to the usual determinations of the horizontal and vertical flexure by use of collimators, a series of star observations, direct and reflected, in both clamps, was made, which gave results confirming those previously determined from the collimators.

The division error work, including the determinations of the correction for division error of each 2′ division of Circle B, was finished March 28, 1908. The probable error of the correction to the mean of four microscopes is 0.″04.

The reductions of the observations are further advanced than for several years past. The apparent declinations are finished to March, 1908, except the corrections for division error, flexure, and variation of latitude. The right ascensions are ready for the application of the clock correction up to October, 1907. The clock corrections are collected to September, 1907, and adopted to September, 1906. The reductions to mean place are computed to April, 1907.

The regular observers during the year have been Assistant Astronomer H. R. Morgan; Assistant (now Professor) Asaph Hall, to March 17, 1908; Assistant C. W. Frederick, from March 17, 1908; and Assistant (temporary appointment) Jesse Pawling, jr.

The observations of the zodiacal stars and of the stars for the determination of instrumental flexure were made by Prof. W. S. Eichelberger, U. S. Navy.

THE 6-INCH TRANSIT CIRCLE.

No observations have been made with this instrument during the past year. Various parts of the instrument, especially the pivots and circles, having deteriorated during the time which had elapsed since observations with it were discontinued on September 4, 1903, measures have been taken to put the instrument in good order for the determination of absolute positions of the sun and fixed stars.

During the year a wooden house to cover the south mark pier has been constructed.

THE CLOCKS.

The Riefler clocks in air-tight glass cases have continued to give satisfaction during the year. A definitive discussion of the rates of Riefler clock No. 70 from February 6 to June 21, 1905, has been completed. During this period the clock case was sealed and apparently no air entered or left the case, the changes that occurred in the pressure being due, presumably, to changes of temperature.

Assuming the clock rate to vary with the reading of the barometer in the clock case and with the time, the following expression was obtained from the observed rates for the daily rate of the clock:

$$R = +0\overset{s}{.}00254 - 0\overset{s}{.}01244\,(B - 677\overset{mm}{.}5) - 0\overset{s}{.}000365\,(T - \text{Apr. } 14.5).$$

The mean deviation of the computed from the observed daily rate for the period is $0\overset{s}{.}009$.

THE NEW CLOCK VAULT.

The construction of a shingle roof over this vault has stopped the leaking which had arisen through faulty construction. A new gas stove has been installed in the hot-water heating system and the amount of heating surface has been increased.

During June, 1908, the vault was kept closed and in all respects as it would be kept if the clocks were installed, except that no thermostat had yet been put in and the gas stove was in constant operation. At the end of the month, there was a difference of 6° F. between the wet and the dry bulb thermometers. The temperature in the corridor surrounding the vault and where the hot-water pipes are located had reached 98°.

Observations will be continued during the summer to see if the vault will remain sufficiently dry, and during the coming winter to determine if the heating plant is powerful enough to maintain a temperature of 75° in the vault throughout the entire year.

THE ALT-AZIMUTH.

Prof. F. B. LITTELL, U. S. Navy, in charge.

There were made with this instrument, used as a vertical circle, during July, 1907, 116 declination observations of stars in Newcomb's Suggested List of Fundamental Stars.

On July 17, 1907, the instrument was dismounted, preparatory to the construction of a new house for which Congress had appropriated $3,000. The new house embodies the latest ideas in the construction of a shelter for an instrument to be used for declination work, inasmuch as it leaves the instrument practically in the open air during observing. The roof sections move entirely off the building, leaving a free space 14 feet wide, with side walls only as high as the axis of the instrument, which act as a wind-break but do not prevent a distribution of air temperature conforming closely to that outside.

As stated in the last annual report, it was proposed to have the vertical circle of this instrument regraduated, and it was hoped that the regraduation could be done during the period the house was being built. However, it happened that the Warner & Swasey Company, the makers of this instrument, were moving their graduating engine, and it was not until March, 1908, that the circle was sent to them upon receipt of word that they were ready for the work. The circle has not yet been returned to the observatory. In order to do away entirely, if possible, with the troubles experienced in the use of silver divided strips, especially in connection with a steel circle, after considerable correspondence and some experimentation, it was decided to use a gold-silver alloy (80 per cent gold and 20 per cent silver) for the graduated surface and to copper-plate and then silver-plate the steel circle before inlaying the gold strip.

Prof. F. B. Littell, U. S. Navy, has been the only observer assigned to this instrument.

Since December, 1903, when Professor Littell commenced to observe with the alt-azimuth, he has made about 5,400 observations, and they are about one-half reduced at the present time.

Before December, 1903, Mr. Hill had accumulated 2,500 observations with this same instrument, but these are practically unreduced.

THE 26-INCH AND 12-INCH EQUATORIALS.

As stated above these instruments were under the general charge of Prof. A. N. Skinner, U. S. Navy, until July 10, 1907, and subsequently they were under the general charge of Prof. W. S. Eichelberger, U. S. Navy.

The number of observations from July 1, 1907, to June 30, 1908, with the 26-inch equatorial is as follows:

Satellites of Mars	18
Satellites of Saturn	189
Satellites of Uranus	29
Satellite of Neptune	13
Phenomena of Saturn's satellites	4
3 comets	15
58 asteroids	241
Double stars	4
Miscellaneous stars	3
Occultations of stars by moon	13
Total	529

The reduction of the observations is practically up to date. The observations of the satellites of Saturn and of the satellite of Neptune, as well as those of the satellites of Uranus made in 1907, have been communicated to the astronomical journals for publication. The printer's copy for a volume to include all the equatorial observations from 1894 to 1907, inclusive, is nearly completed.

Determinations of the orbits of several asteroids have been made during the year.

An electric motor for turning the dome has been installed, and works very satisfactorily.

On May 20, 1908, the object-glass of the 26-inch equatorial was removed from its cell, cleaned, replaced, and adjusted by Mr. C. A. R. Lundin.

The observers during the year have been Prof. H. L. Rice, U. S. Navy, to September 21, 1907; Prof. Asaph Hall, U. S. Navy, from March 20, 1908; Assistant Astronomer J. C. Hammond and Assistant Matt Frederickson throughout the year.

The number of observations secured with the 12-inch equatorial from July 1, 1907, to June 30, 1908, is as follows:

13 asteroids	39
2 comets	5
Occultations of stars by moon	14
Phenomena of Saturn's satellites	3
Total	61

These observations were made by Assistant Matt Frederickson, except three comet observations by Assistant Astronomer H. L. Rice, and the phenomena of Saturn's satellites by Assistant George H. Peters.

On May 20 and 21, 1908, the object-glass of the 12-inch equatorial was removed from its cell, cleaned, replaced, and adjusted by Mr. C. A. R. Lundin.

The number of visitors received by permit during the year for a view of the heavens with the 12-inch equatorial is 1,708.

THE PRIME VERTICAL TRANSIT INSTRUMENT.

Assistant Astronomer G. A. Hill, in charge.

As in previous years Mr. Hill has been the only observer on this instrument during the year.

The same method has been used in observing with this instrument as has been outlined in former reports, i. e., to observe for variation of latitude, 16 stars, divided into four groups of four stars each, the mean right ascensions of the four groups being six hours, fourteen hours, eighteen hours, and twenty-two hours. The instrument is in good working order, and only a few minor repairs have been necessary. There were made during the year 599 observations.

The observations already made are reduced, checked, and transscribed on the printer's copy to January 1, 1906. The observations are reduced to mean place to October 25, 1907.

THE PHOTOGRAPHIC EQUATORIAL AND PHOTOHELIOGRAPH.

Assistant George H. Peters, in charge.

The photographic equatorial was described in the Superintendent's annual report for the fiscal year ending June 30, 1905. In March, 1908, there was added to its battery of cameras an 8½-inch visually corrected lens of 12 feet focal length. This lens was the one used in the transit circle at the old observatory. All the work necessary to the mounting of this lens was done by Mr. Peters.

The instrument has been employed principally for finding asteroids to be observed micrometrically either with the 26-inch equatorial or the 12-inch.

Eighty asteroid fields have been photographed with this instrument during the year, in some cases several asteroids being found on the same plate.

The sun has been photographed with the photoheliograph on one hundred and seventy-nine days, and solar spots were observed on every day but two. The photographs show a considerable decrease both in the number and in the size of the solar spots and groups. The total number of solar negatives now on hand made with this instrument is 1,634.

Mr. Peters has worked without assistance on these instruments.

THE TRANSIT OF MERCURY.

Four observations each of the III and IV contacts of the transit of Mercury were obtained on the morning of November 14 by Prof. W. S. Eichelberger, Assistant Astronomer G. A. Hill, Assistant Astronomer J. C. Hammond, and Assistant Matt Frederickson. Twelve photographs of the transit were obtained by Assistant G. H. Peters.

THE PARTIAL SOLAR ECLIPSE.

Five observations each of the I and II contacts of the partial solar eclipse were obtained on June 28 by Prof. F. B. Littell, Assistant Astronomer G. A. Hill, Assistant Astronomer J. C. Hammond, Assistant C. W. Frederick, and Assistant Matt Frederickson. Seven photographs of the sun during the eclipse were obtained by Assistant G. H. Peters.

ASTRONOMISCHE GESELLSCHAFT ZONE CATALOGUE —13° 50′ TO —18° 10′.

The printer's copy of this catalogue and the introduction was sent October 21, 1907, to Doctor Ristenpart, Berlin, Germany, who has charge of the publication for the Gesellschaft. The proof sheets were read both by Doctor Ristenpart and the Naval Observatory, and the last sheets were returned to Berlin May 27, 1908. It is expected that the completed volume will be published by the Astronomische Gesellschaft of Leipzig, Germany, during August, 1908.

This catalogue contains 8,824 stars observed by Prof. A. N. Skinner on the 9-inch transit circle 1894–1905, and forms the fourth volume of the second division of the catalogue of the Astronomische Gesellschaft which embraces all stars to the ninth magnitude between 23° south and 80° north declination.

Professor Skinner is now engaged in preparing material to be used in discussing the proper motions of the stars in this catalogue. This material is intended to embrace the data from all accessible star catalogues.

THE WASHINGTON ZONE CATALOGUE. 1846–1852.

All of the published observations have been compared with the Cordoba General Catalogue, and where there were sufficient stars in common, zone corrections have been deduced and applied.

The 5,000 errors furnished from different sources as mentioned in the annual report for the fiscal year ending June 30, 1903, and many others discovered during the last five years, have been examined and the necessary corrections to the observations made. During this work it was found that frequently transit threads which gave quite discordant results when reduced to mean thread were combined to give the published right ascension of the star, so that it was decided to re-reduce all transits. This has been finished for the transit and meridian circle zones, and is in progress for the mural zones. This investigation has revealed a large number of discordant threads.

The reduction of the 7,000 unpublished observations of 1847, 1848, 1851, and 1852 by Professor Littell is nearly completed, and a large part of these observations has been compared with the Cordoba General Catalogue in order to obtain the zone corrections.

DISCONTINUANCE OF THE BRANCH OBSERVATORY AT TUTUILA, SAMOA.

The branch observatory at the naval station, Tutuila, Samoa, established by an order of the Navy Department dated February 8, 1904, and intended for astronomical and magnetic work, was discontinued by an order of the department dated January 28, 1908. This was done for the reason that the climatic and terrestrial conditions have been found by practical experience to be such that there is no hope that the expectations with which that observatory was established could ever be realized.

Mr. C. W. Frederick, assistant U. S. Naval Observatory, was in charge of the Tutuila Observatory from September, 1904, to October, 1906, and Mr. Benjamin Boss, also an assistant here, was in charge from the latter date until the observatory was closed in May, 1908.

The reports of Mr. Frederick and of Mr. Boss, which are on file here, agree in showing that high winds, dense clouds, bad seeing, and an almost total absence of really clear weather, together with instability of the foundations of the observatory due probably to the beating of the waves on the seashore, rendered the site unsuitable for astronomical observations. The magnetic character of the volcanic formation of the island makes the site equally unsuitable for magnetic observations, and the existence of an active magnetic observatory maintained by the German Government on the neighboring island of Apia renders such observations unnecessary at Tutuila.

The closing of this observatory is further justified by the fact that the instrumental equipment both for astronomical and magnetic work was inadequate, and the conditions for living there were so unfavorable as to make necessary so frequent an exchange of observers as to impair whatever efficiency the observatory might otherwise have had.

PUBLICATIONS.

As showing the contributions to astronomy in general in other than government publications, the following list of articles made public is submitted:

In the *Astronomische Nachrichten*, Nr. 4226: "Ephemeris of minor planet (611) (1906 VL)," by Matt Frederickson.

In the *Astronomische Nachrichten*, Nr. 4232: "Asaph Hall," by W. S. Eichelberger.

In the *Astronomische Nachrichten*, Nr. 4234: "Elements and finding ephemeris of planet 1906 VM," by Eleanor A. Lamson.

In the *Astronomische Nachrichten*, Nr. 4240: "Ephemeris of minor planet (622) (1906 WP)," by Matt Frederickson.

In the *Astronomische Nachrichten*, Nr. 4245: "Elements and ephemeris of (581) Tauntonia," by H. [illegible]. Morgan.

In the Astronomical Journal, No. 596: "Elements of planet 1907 XZ," by Eleanor A. Lamson.

In the Astronomical Journal, No. 598: "Elements and ephemerides of planet 1907 XP," by Asaph Hall, jr.

In the Astronomical Journal, No. 599: "Elements and ephemeris of comet *d* 1907 (Mellish)," by Eleanor A. Lamson.

In the Biographical Memoirs of the National Academy of Sciences, Vol. VI, pp. 276–309: "Published writings of Asaph Hall," by W. D. Horigan.

In the Veröffentlichungen des Königlichen Astronomischen Rechen-Instituts zu Berlin, No. 32: "Elements and ephemeris of 599 (1906 VI)," by Matt Frederickson.

Also in the Astronomical Journal and Astronomische Nachrichten numerous observations of satellites, asteroids, and comets, and the observations of the transit of Mercury, November 14, 1907.

THE NAUTICAL ALMANAC OFFICE.

This office continued under the direction of Prof. W. S. Harshman, U. S. Navy, until October 1, 1907, when he was succeeded by Prof. Milton Updegraff, U. S. Navy.

On July 1, 1908, Mr. James Robertson was advanced from assistant at $1,600 to assistant at $1,800 to fill a position at that salary established by Congress this year. Mr. G. F. Crawley, of Columbia, S. C., was appointed a piecework computer on December 19, 1907. On February 12, 1908, Miss Isabel Martin, of Washington, D. C., was appointed a piecework computer by transfer from the eligible list for miscellaneous computer, U. S. Naval Observatory. Mr. Thomas E. Trott, of Scio, Ohio, was appointed piecework computer on June 15, 1908.

The duty of distributing the American Ephemeris and Nautical Almanac and the American Nautical Almanac to the ships of the navy has been transferred by the Chief of the Bureau of Equipment from the Hydrographic Office of the Navy to the Nautical Almanac Office, beginning with the issues of these publications for the year 1909.

The list of astronomical observatories and of other institutions both domestic and foreign to which the American Ephemeris and Nautical Almanac and the Astronomical Papers are sent has been considerably increased. The number of astronomers and of other persons of scientific reputation and standing to whom the Astronomical Papers are sent free has been largely increased, but, with the exception of a very few cases, the American Ephemeris and Nautical Almanac is not sent free to individuals.

As stated in the last report, all of the publications of the office, including the Astronomical Papers of the American Ephemeris, Volumes I to VIII, are kept for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C. They are no longer sold by the Nautical Almanac Office. Volume I of the Astronomical Papers has been out of print in this country for some years, but 107 copies belonging to the office have recently been procured from certain booksellers in Europe to whom they had been sent in 1882 to be sold, and are now for sale by the Superintendent of Documents, as noted above.

Two parts of Volume IX of the Astronomical Papers of the American Ephemeris, entitled "Tables of the Satellites of Saturn," and "Tables for the Transformation of Longitude and Latitude into Right Ascension and Declination for the Sun and Moon," which have been prepared during the past few years, are ready for the press. Their publication has been delayed by a deficiency in the printing fund of the Navy Department for the last fiscal year. The material for a third part of Volume IX is now being prepared.

A considerable amount of work is being done by the office in cooperation with Prof. Simon Newcomb, U. S. Navy (retired), in continuation of his researches on the motions of the Moon and the planet Mars, which were commenced while Professor Newcomb was Director of the Nautical Almanac.

The American Ephemeris and Nautical Almanac for the year 1911 was distributed in April, 1908. It differs only slightly from the issues for several years past, but preparations are being made for various changes in the volume for the year 1912, some of the more important of which are as follows:

(*a*) The tables of lunar distances will be omitted hereafter. Inquiries made in October, 1907, by the Chief of the Bureau of Equipment, developed the fact that these tables are practically no longer used by the navigators of either the naval service or of the merchant marine, and authority has been given for their omission beginning with the volume for 1912.

(*b*) The omission of the lunar-distance tables will make available for other matter about 74 pages of the American Ephemeris and Nautical Almanac, and this space will be utilized by increasing by about 300 the number of ephemerides of fixed stars, thus raising the total number of such stars of which the apparent places are given to about 700. These stars and their mean places in right ascension and declination for the beginning of the year are taken from Newcomb's Fundamental Catalogue.

(*c*) Beginning with the volume for the year 1912, the constants of precession, nutation, and aberration and the obliquity of the ecliptic adopted by the Paris conference of 1896 will be used instead of the Struve-Peters values of these constants which have been used hitherto in the body of the book.

(*d*) The increased speed within recent years of vessels both of the navy and of the merchant marine makes necessary an increased use of observations of the fixed stars and of the planets, especially in connection with Sumner's Method. In order to make such observations more convenient, a pamphlet containing monthly lists of bright stars and planets with their positions and other data for the year 1908 was prepared in the Nautical Almanac Office in November, 1907, and was issued in December to the ships of the navy, including the vessels of the fleet before it sailed from Norfolk, Va., on December 16. This was done by way of experiment, and if they are found to be of practical value these monthly lists, together with certain auxiliary tables, will be incorporated in the American Nautical Almanac for 1912 and for subsequent years.

There have been received during the year from the Government Printing Office 904 copies of the American Ephemeris and Nautical Almanac for 1908, second edition; 3,500 copies of the American Nautical Almanac for 1908, second edition; 500 copies of Stars for Navigators for 1908 (supplement to the American Ephemeris and Nautical Almanac for 1908, first edition), and 1,550 copies second edition; 1,000 copies of the American Ephemeris and Nautical Almanac for 1911, first edition; 500 copies of the American Nautical Almanac for 1911, first edition.

The distribution of the publications of the Nautical Almanac Office during the year is shown in the following table:

	Naval service.	Other departments.	Superintendent of documents.	Free distribution.	Total.
American Ephemeris and Nautical Almanac	544	336	1,000	647	2,527
American Nautical Almanac	424	35	4,089		4,548
Astronomical Papers			28	819	847
Stars for Navigators	846	31	510	94	1,481

DEPARTMENT OF NAUTICAL INSTRUMENTS AND GENERAL STOREKEEPER.

The department was in charge of Commander T. D. Griffin, U. S. Navy, until August 8, 1907, when he was detached for duty as commanding officer, U. S. S. *Paducah;* Commander A. G. Winterhalter, U. S. Navy, was in charge of the department from September 9, 1907, to May 17, 1908, when he was detached and placed in charge of the Hydrographic Office. Assistant E. A. Boeger was in charge during the remainder of the fiscal year.

The following is a brief summary of the work of this department during the fiscal year:

Value of stock on hand July 1, 1907	$100,000.00
Value of instruments, etc., purchased	$48,133.37
Value of articles received from navy-yards, etc.	$126,209.83
Value of articles issued	$150,205.84
Value of stock on hand June 30, 1908	$124,137.36
Number of shipments made	506
Number of instruments, etc., shipped	5,698

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department was in charge of Commander E. E. Hayden, U. S. Navy.

The regular annual chronometer trial began January 6, 1908, and ended June 8, 1908. The total number of instruments under trial, the largest on record, was as follows: Thirty-five new chronometers, 38 new torpedo-boat watches, 103 old naval chronometers, 14 old torpedo-boat watches, 6 chronometer watches, 4 comparing watches, and 7 sample watches of various types, a grand total of 207.

The accompanying tabular statements, Tables I, II, and III, give all the data and results of the trial for those instruments that were received in time and that obtained a trial number of 25 or less.

The regular work of the department in connection with the rating and issue of chronometers, the testing of new chronometers, watches, and clocks, and the sending out of the daily telegraphic time signals has been heavier than usual during the year.

The mean daily error of the noon signal for the year was $0^{s}.054$, the maximum error on any day being $0^{s}.36$.

In connection with the New Year's Eve telegraphic time signals, which were sent out as usual, it is of interest to note the fact that their apparent receipt at the Mare Island Navy-Yard $0^{s}.36$ too early resulted in a redetermination of the longitude of that observatory by the exchange of observers and telegraphic signals with Lick Observatory. The former accepted value, $8^{h}\ 09^{m}\ 05^{s}.29$, was thus changed to $8^{h}\ 09^{m}\ 05^{s}.63$ west from Greenwich. The close agreement of the error, $0^{s}.34$, with that indicated by the too early receipt of our time signals, $0^{s}.36$, is a remarkable confirmation of the rapidity and accuracy with which our signals were transmitted across the continent by the Western Union Telegraph Company, which also sends them daily to all of the naval time-ball stations.

COMPASS OFFICE.

The personnel of the office has been as follows: From July 1, 1907, to March 18, 1908, Commander Thomas Snowden, U. S. Navy, superintendent of compasses; from March 1, 1908, to March 18, 1908, Lieut. Commander J. S. Doddridge, U. S. Navy, assistant; from March 18, 1908, to June 30, 1908, Lieut. Commander J. S. Doddridge, U. S. Navy, superintendent of compasses.

LIBRARY.

	Volumes.	Pamphlets.	Total.
Contents of library July 1, 1907	20,912	4,369	25,281
Accessions	563	84	647
Contents July 1, 1908	21,475	4,453	25,928

Of the accessions, 364 were received as exchanges and 283 were purchased. There were distributed 1,110 copies of the various publications of the observatory. The routine work is up to date.

The observatory has been much inconvenienced in its administrative functions through the need of certain, usually considered necessary, works of reference. For example, owing to various decisions of the Comptroller of the Treasury, the observatory can not pay for the Directory of the District of Columbia out of any of its present funds.

BUILDINGS, GROUNDS, AND ROADS.

All buildings except the main building are in good condition. An appropriation was made for the necessary repairs on the main building, and this work will be completed the coming fall.

The roads have been kept in repair and 450 feet of new concrete walk has been laid.

The high bank on Massachusetts avenue has been graded and a deep ravine on the north side of the grounds filled so as to make a new road of easy grade to Massachusetts avenue.

The following improvements have been made in the sewerage system: All cesspools have been filled up and 1,400 feet of new sewer pipe laid and connected with the District system.

alances (specification No.
8.

ater than 25 omitted.

	Chronometer room. (Or		
0.01	**67.53**	**69.59**	**69.32**
50	**55**	**48**	**43**
ar. 19 to ar. 26.	Mar. 30 to Apr. 6.	Apr. 6 to Apr. 13.	Apr. 13 to Apr. 20.
s.	*s.*	*s.*	*s.*
−0.39	−1.74	−1.66	−1.69
−0.60	−2.03	−2.01	−1.99
+1.87	+0.76	+0.74	+0.73
+1.73	+0.16	−0.01	−0.06
+1.30	−0.03	−0.09	−0.11
+2.31	+0.64	+0.69	+0.54
+0.86	−0.30	−0.20	−0.26
+0.03	−1.26	−1.47	−1.29
+1.24	+0.20	+0.13	−0.11
+0.16	−1.27	−1.33	−1.44
−1.10	−1.19	−1.26	−1.33
+2.13	0.00	−0.14	−0.11
+4.39	+3.10	+2.81	+2.46
−0.60	−1.60	−1.73	−1.84
+1.51	0.00	−0.09	−0.16
+1.33	+0.27	+0.04	−0.10

th

wh
the
res
by
Ob
ch
me
of
an
con
sen

T
to
int
Lie
Ma
dri

Conte
Acces

O
pur
licat
T
trat
nece
sion
pay
pres

A
An
buil
Th
walk
Th
deep
a ne
Th
syste
pipe

TA

United States Naval Observatory, Wa

eater than 25 omitted.

Order of	Chronometer room. (Orientation ch				
T	0.01	67.53	69.59	69.32	69.80
R	50	55	48	43	54
	ar. 19 to ar. 26.	Mar. 30 to Apr. 6.	Apr. 6 to Apr. 13.	Apr. 13 to Apr. 20.	Apr. 20 to Apr. 27.
	s.	*s.*	*s.*	*s.*	*s*
	−0.24	−0.13	−0.37	−0.31	−0.33
	+1.26	+0.91	+1.07	+1.16	+0.99
	+0.37	−0.19	+0.13	−0.24	−0.50
	−0.11	−0.93	−0.91	−0.84	−0.91
	−0.43	−0.87	−0.80	−0.59	−0.76
	+1.20	+0.40	+0.64	+0.60	+0.59
	+1.96	+2.70	+2.67	+2.71	+2.80
	−2.57	−3.01	−3.16	−3.16	−3.41
	−0.64	−0.90	−0.74	−0.94	−1.06
	−4.40	−4.93	−4.67	−4.90	−5.01
	+0.47	+0.97	+0.90	+1.09	+1.11
	+0.57	+0.73	+0.89	+1.07	+1.17
	+1.00	+0.86	+0.73	+1.14	+0.83
	−1.14	−2.33	−2.09	−2.04	−2.04
	−2.89	−3.30	−2.90	−2.97	−2.76
	+0.79	+0.73	+1.04	+0.90	+0.94

th

wh
the
res
by
Ob
ch
me
of
an
co
ser

to
int
Lie
Ma
dri

Conte
Acces

O
pur
lica
T
trat
nec
sion
pay
pres

A
An
buil
T
walk
Th
deep
a ne
Th
syst
pipe

tory, Washington, D. C., Jo

reater than 25 omitted.

		)	Chronometer room. (O		
Temper		90.01	67.53	69.59	69.32
Relativ		50	55	48	43
Order of merit.		Mar. 19 to Mar. 26.	Mar. 30 to Apr. 6.	Apr. 6 to Apr. 13.	Apr. 13 to Apr. 20.
		s.	*s.*	*s.*	*s.*
1	Ne	+3.74	+4.00	+3.94	+4.07
2	Le	−1.60	−1.89	−2.03	−2.03
3	Ne	+1.97	+1.76	+1.60	+1.56
4	....	+1.49	+0.13	+0.03	−0.03
5	....	+0.90	+0.70	+0.44	+0.64
6	Bo	+3.01	+1.44	+1.39	+1.31
7	Ne	+1.11	−0.03	−0.16	−0.16
8	Bo	+0.13	−0.43	−0.33	−0.50
9	....	+0.83	−0.64	−0.84	−0.81
10	Ne	+3.74	+2.54	+2.47	+2.41
11	Bo	+1.86	+0.41	+0.56	+0.67
12	Po	+0.59	−1.40	−1.37	−1.29
13	Ne	+0.86	+0.23	+0.29	+0.19
14	....	+2.49	+1.01	+1.00	+0.93
15	Bli	+2.34	+2.60	+2.47	+2.26
16	....	+2.54	+0.87	+0.89	+0.77
17	Ne	+0.46	−0.81	−0.86	−0.89
18	....	+3.11	+1.94	+1.77	+1.61
19	Bo	+1.21	−0.04	−0.17	−0.23
20	Fa	+2.17	+0.66	+0.47	+0.51
21	Joh	+1.90	+1.80	+1.73	+1.66
22	Ne	+3.57	+1.83	+1.86	+1.84
23	....	+2.70	+1.86	+1.69	+1.56
24	Bo	+1.57	+0.76	+0.64	+0.47
25	....	+0.26	−0.49	−0.61	−0.56
26	....	+1.34	+0.91	+0.77	+0.86
27	De	−0.04	−0.63	−0.51	−0.61
28	Ne	+3.04	+1.36	+1.29	+1.26
29	Hel	+0.81	−0.04	−0.16	−0.31
30	Blis	+0.83	+1.26	+1.23	+1.47
31	Neg	+1.90	+0.91	+0.73	+0.73
32	Bli	+2.37	+0.70	+0.70	+0.53
33	....	+2.74	+1.04	+0.84	+0.86
34	Sew	+2.59	+1.41	+1.37	+1.30
35	Bar	−1.51	−1.37	−1.73	−1.83
36	Neg	+1.96	+0.73	+0.51	+0.61
37	....	−0.71	−2.43	−2.60	−2.74
38	Poc	+2.50	+1.60	+1.43	+1.37
39	Neg	+1.24	+0.39	+0.24	+0.11
40	....	+3.91	+2.07	+2.14	+2.06
41	....	+1.66	+0.51	+0.56	+0.51
42	....	+1.09	−0.54	....	....
43	Bo	+2.17	+0.60	+0.59	+0.51
44	Ne	+1.93	+1.34	+1.40	+1.56
45	Bo	−0.41	−3.17	−3.04	−3.09
46	Ne	+3.31	+2.97	+2.97	+3.07
47	Me	+0.56	−0.67	−0.99	−0.91
48	Bo	+3.06	+2.40	+2.14	+2.43
49	Ba	+0.70	+0.31	+0.21	+0.13
50	Bl	−0.44	−0.71	−0.94	−0.87
51	Ne	+0.41	−0.64	−0.81	−1.07
52	Bo	+3.64	+2.46	+2.36	+2.30
53	Ne	+3.41	+0.49	+0.81	+0.76
54	Bo	+1.33	+2.44	+2.11	+2.07
55	Ku	−1.90	−2.63	−2.00	−2.86
56	De	−0.44	−1.21	−0.86	−0.87
57	Le	+2.11	+0.10	+0.10	+0.09
58	Bl	+1.41	−0.76	−0.80	−0.94
59	Ne	+1.10	−0.71	−0.51	−0.59
60	....	+1.91	+0.04	−0.13	−0.06
61	....	+2.40	+1.66	+1.26	+1.04
62	....	−0.61	−1.37	−1.53	−1.10
63	Bo	−0.76	+0.57	+0.30	+0.29
64	Bl	+1.50	−0.49	−0.46	−0.56
65	De				

th

w
th
re
b
O
ch
m
of
ar
co
se

to
in
Li
M
dr

Con
Ac

pu
lic

tr
ne
sic
pa
pr

Ar
bu

wa

de
a

sy
pi

NAVY DEPARTMENT
UNITED STATES NAVAL OBSERVATORY

SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30

1909

GOVERNMENT PRINTING OFFICE
WASHINGTON
1910

SYNOPSIS OF THE REPORT

OF THE

SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1909.

Rear-Admiral W. J. Barnette, U. S. Navy, continued as Superintendent until his death on April 19, 1909. Capt. T. E. De Witt Veeder, U. S. Navy, assumed the duties of Superintendent on April 20, 1909.

In March, 1909, the Secretary of the Navy issued the following instruction with regard to the methods, purposes, and scope of work of this institution:

The following order of the Superintendent of the United States Naval Observatory, organizing the astronomical council and defining its duties, together with certain features of the plan of astronomical work now in force there, are hereby established as a part of the administrative system of that institution.

U. S. Naval Observatory,
Washington, D. C., July 29, 1908.

Order.

There is hereby formed an astronomical council composed of the following members: The Superintendent (ex officio), the Assistant Superintendent, such assistants in charge of the astronomical divisions as the Superintendent may designate, and the Director of the Nautical Almanac.

The council should be guided by the fact that the most important astronomical duty of the Government is the publication of the Nautical Almanac, and as that is intended not only for the use of navigators, but also of astronomers in the most delicate investigations known to their science, it should be kept up to the highest attainable pitch of accuracy. To that end, continuous fundamental meridian observations upon the sun, moon, planets, and stars are absolutely necessary and constitute the astronomical essentials.

The council shall advise the Superintendent on the following subjects:

1. The coordination and cooperation of the work of the Department of Astronomical Observations and of the Nautical Almanac Office.
2. Suggested variations from the plan of astronomical work prescribed by the regulations.
3. Methods to be used in the prosecution of the astronomical work.
4. Condition of and changes proposed in instrumental equipment.
5. The assignment of the scientific personnel to give the best possible results. The assignment of computers should be so made as to balance the work of the observers and computers, in order that observations may be expeditiously published.
6. The character and astronomical value of the observations and their publication.
7. Promotions, transfers, and filling of vacancies.
8. The yearly estimates for submission to the Secretary of the Navy.
9. The expenditure of the appropriations for astronomical and scientific purposes.
10. A system by which the cost of any piece of work may be readily available.

Of the above-enumerated subjects, those relating to the Nautical Almanac Office shall be considered first by the director of that office, those relating to the Department of Astronomical Observations shall be considered first by an executive committee, and the conclusions of both shall be submitted to the council.

There shall be formed an executive committee of the council, consisting of three heads of divisions of the Department of Astronomical Observations, to be designated by the Superintendent.

The executive committee shall have charge of all editing and printing pertaining to the Department of Astronomical Observations, and in addition shall undertake any other duties which may be assigned to it by the Superintendent or by the council.

The executive committee shall audit the accounts of the observatory arising from the expenditure of appropriations coming under the following subheads: Miscellaneous computations, Department of Astronomical Observations; professional and scientific books; apparatus and instruments and for repairs of same.

The heads of divisions of the Astronomical Department shall submit their monthly reports of progress to the Superintendent, and these shall be laid before the council.

The council shall meet monthly, except in August, and at such other times as the Superintendent may direct.

A clerk shall be detailed to act as secretary of the council and of the executive committee, who shall keep minutes of each meeting in a book or other proper file.

Should the Superintendent not act on the advice of the council, he shall give his reasons therefor, and they shall be entered upon the minutes.

W. J. Barnette,
Captain, U. S. Navy, and Superintendent Naval Observatory.

The astronomical work of the Naval Observatory shall be so planned and executed as best to subserve the following purposes, and no others, to wit:

To furnish to the Nautical Almanac Office, as far as may be possible, such observations and such data as may be needed for carrying out the purpose of the law under which the appropriations for that office are made from year to year, which is as follows:

> For * * * preparing for publication the American Ephemeris and Nautical Almanac and improving the tables of the planets, moon, and stars * * *.

The principal work of the observatory shall be in the field of the astronomy of position as distinguished from astrophysical work, and shall be the continued maintenance of observations for absolute positions of the fundamental stars and of stars which are to be made fundamental, and in addition the independent determination by observations of the sun, of the position of the ecliptic, and of the equator among the stars, and of the positions of the stars, moon, and planets with reference to the equator and equinoxes.

(Signed) Truman H. Newberry,
Secretary.

The duties of the institution have been so arranged, that it is believed entirely satisfactory results will be attained, while the operations will move with a common purpose known to the entire staff. The council has held its regular meetings and special meetings for the consideration of matters requiring prompt action.

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

DIVISION OF THE 6-INCH TRANSIT CIRCLE.

This division was in charge of Prof. M. Updegraff, U. S. Navy, except for the first four weeks of the fiscal year, when Prof. W. S. Eichelberger, U. S. Navy, was in charge.

The Board of 1908 on Plan and Scope of Work submitted:

> That the Superintendent be advised to have the pivots of the 6-inch transit circle reground, and the divided circles put in good condition, if possible without redivision, and to have such other repairs made as may be found to be necessary to put the instrument in good condition for fundamental work in both right ascension and declination in order that the instrument may be thoroughly and exhaustively tested for its fitness for such work.

In August, 1908, the instrument was dismounted and sent to The Warner & Swasey Co. for the work recommended. It was necessary to take off about 0.006 inches of the diameter of the pivots in order to remove all traces of rust spots. The pivots were then tested and found to be so regular in form as to be highly satisfactory. By January, 1909, the whole instrument was returned and mounted in the following month.

In addition to the above-mentioned repairs, Circle B was so fitted on its bearings on the axis that it can be conveniently rotated, but is at the same time held in position with sufficient firmness by friction. This arrangement has been found to be very satisfactory.

The holes in the pivots were enlarged from 1 to $1\frac{1}{4}$ inches in diameter, and an axial collimator lens of $1\frac{3}{16}$ inches clear aperture was provided. Numerous minor improvements in the instrument were made.

While the instrument was undergoing repairs, the brick piers were painted with two coats of asphalt varnish and covered with two layers of asbestos felt. They were then incased with cherry boards, dressed, tongued and grooved, and seven-eighths of an inch thick. This casing was fastened to, and is supported by, the piers themselves, and is separated from the floor of the building by a clear space of about one-fourth of an inch, which space is closed with felt weather strips to prevent circulation of air.

The silver strip, which is inlaid in the steel circles, and which bears the divisions, had become corroded by rust from the steel and was disfigured by a number of scratches, which in a number of cases affected the divisions. These circles were gone over and the damage repaired as far as was practicable.

The contact points of the transit micrometer, which had been too close together were changed so that the signals on the chronograph made in the observation of a star on the equator are $0^{s}.7$ apart. There are 10 such signals, the middle being shown by a double space for the purpose of identification. It may be mentioned here that in June, 1909, the transit micrometer was returned to The Warner & Swasey Co. for rearrangement of the reticule of fixed wires, in order to make it convenient for observations of the sun, the moon, and the stars. In addition to this, repairs of the reticule which had become necessary were made.

The illumination of the field of the 6-inch transit circle, which had been changed in the year 1901 so as to illuminate the field by light reflected from a mirror cemented on the inner surface of the object-glass, was changed again a few years ago, the mirror being placed on the outside of the object-glass. After many futile attempts to adjust the illumination and make it satisfactory with this arrangement, it was found to be necessary, in March, to change back to the mirror on the inside of the object-glass. The light reflected from the mirror on the outside of the object-glass formed into an image in passing through in such a way that the diaphragm which regulates the brightness, instead of modifying the brightness of the general illumination, cut the light off from a portion of the field, leaving the remainder bright. The illumination of the field is now satisfactory and can be easily and quickly adjusted from great brilliance to total darkness.

The telescope was found to be imperfectly balanced, the object-glass end being too light, and on May 11 a lead weight weighing 4⅜ ounces was fastened inside the object-glass end of the tube.

In June, when an attempt was made to bring the vertical collimator apparatus into use, it was found necessary to shorten the tube of the telescope by 2 inches in order to focus it.

The errors of the instrument have been partially investigated in the process of determining the fitness of the instrument for fundamental work, as required by the resolution of the Board of 1908 on Plan and Scope of Work, quoted above.

The spherometer caliper measures of the pivots have shown their form to be satisfactory, and the difference in size between the two pivots has been found to be inappreciable. The result thus found, as to the regularity of the form of the pivots, is confirmed by an elaborate series of observations with the axial collimator, by four observers. This work indicates that the axis of the instrument suffers no displacement, as the telescope revolves, which is large enough to cause any appreciable error in the observations in right ascension. The enlargement as noted above of the clear aperture of the axial collimator lens has improved the definition and hence the accuracy of the apparatus.

Two of the microscope micrometer screws have been investigated for periodic errors with the Transit of Venus measuring engine and the errors found are small. It remains to investigate the other screws.

The errors of the 15° lines of both divided circles have been very carefully measured by the method of comparison and will serve as a basis for determining the errors of other divisions of these circles. The results on the 15° lines are as follows:

″	″
$A_{15} = -0.89$	$B_{15} = -0.77$
$A_{30} = +1.00$	$B_{30} = +1.06$
$A_{45} = -0.03$	$B_{45} = -0.04$
$A_{60} = -0.24$	$B_{60} = +0.01$
$A_{75} = -0.91$	$B_{75} = -0.67$

The telescope of this instrument is subject to a change of focus with temperature, which has been carefully observed, and the focus has been adjusted when change of temperature has made it necessary. However, no serious inconvenience or error in the observations has resulted from the change of focus which has occurred. It seems probable that the adjustment of the focus of the telescope will not be needed oftener than two or three times a year.

The nadir point and the constants of azimuth, level, and collimation of the instrument are steady to a satisfactory degree. The instrument was adjusted in azimuth and level for the last time, as far as is known, in the year 1902. When the instrument was mounted last February these constants were found so small that no adjustment was necessary.

In the observations of stars, as in the investigation of the errors of the instrument, the plan for fundamental work as formulated by the Board of 1908 on Plan and Scope of Work above mentioned is being carried out.

The observations of stars which have been made are given in the following table:

Inclination stars	60
Polaris U. C	24
Polaris L. C	34
Circumpolar stars other than Polaris for azimuth	39
Fundamental stars near autumnal equinox (10 in group)	290
Other stars from American Ephemeris and Newcomb's Fundamental Catalogue.	1,473
Total number of observations	1,920

Twenty observations of Polaris U. C. and L. C. twelve hours apart have been made.

The reduction of these observations is practically up to date, but little has been done in discussing them.

The following probable errors have been deduced from observations made from March 15 to March 22: In right ascension, with the new transit micrometers, $+0^{s}.020 \sec\delta$; in declination for Circle A, $+0''.27$; for Circle B, $+0''.64$. The large probable error of Circle B is mainly due to the effect of division errors, which will be removed when the corrections for division errors are applied.

It is expected that very soon the efforts of the staff of this division may be wholly devoted to the fundamental work which is the duty to which it is expected to assign this instrument. At a meeting of the council of June 23, 1909, was considered a plan of work for the fiscal year 1910, and it was recommended:

> That the report of the Board of 1908 on Plan and Scope of Work should be followed out; "the instrument to be put in good condition for fundamental work in right ascension and declination, to be thoroughly tested for its fitness for such work, and if found suited to it to be continuously employed in fundamental work on the sun, stars, and such other objects as may be considered desirable;" that these observations should be conducted for a year, the results reduced and compared with one another and the standard catalogues of precision; that azimuth and latitude be determined morning and evening from successive culminations of the same stars; that reflection observations be made in both right ascension and declination; that the flexure be determined at frequent intervals by horizontal and vertical collimators; that the division errors be determined; that during this year the aim should be not to accumulate a great number of observations, but to demonstrate the ability of the instrument to do first-class work in accordance with the plan proposed.

THE CLOCK VAULT.

This was in charge of Prof. M. Updegraff, U. S. Navy, from July 28, 1908, it having been in charge of Prof. W. S. Eichelberger, U. S. Navy the first four weeks of the year. Mr. Hammond, assistant astronomer, has been in immediate charge since October 3, 1908. Close attention to and intelligent consideration of the difficulties which had prevailed to cause fluctuations in the temperature have removed these troubles and secured practically a constant temperature. The performance of the clocks in the vault is excellent. There has been no inconvenience from dampness or humidity in the vault, and no damage to the mechanism of the clocks has ever resulted from this cause, whether inclosed in air-tight cases or not.

DIVISION OF THE 9-INCH TRANSIT CIRCLE.

This division was in charge of Prof. F. B. Littell, U. S. Navy, from October 1, 1908. For the first three months of the year the instrument was in charge of Prof. W. S. Eichelberger, U. S. Navy.

The Board of 1908 on Plan and Scope of Work recommended for this instrument as follows:

> Continuation of the series of observations now being carried on until finished. If the 6-inch is found to be suitable for the fundamental work for which it was designed, the 9-inch should be used for differential work in observing the moon and planets and fainter stars.
>
> The board is of the opinion that it is advisable to leave to the future a final decision as to the instruments to be used for the sun, moon, and planet work, but that unless later developments should make it seem inadvisable, the transit circles should be employed as indicated above.

The work of the determination of the right ascensions and declinations of the sun, moon, planets, and of the stars of Newcomb's Suggested List of Fundamental Stars was accordingly continued up to May 1, 1909.

On the 29th of April, 1909, the council recommended that the sun, moon, and planet work of this instrument should be done in such a way that it may be reduced fundamentally as well as differentially. Since this date the work has been done accordingly.

The report of the Superintendent for June 30, 1908, gives ten months, or until May 1, 1909, to complete the desired observations of the stars in Newcomb's Suggested List of Fundamental Stars. When this date arrived it was found that the instrument had been used clamp west and that it would be good practice to secure certain possible eliminations by continuing these observations for another year clamp east. The work is therefore proceeding.

On June 23, 1909, the council recommended the following plan of work for this instrument for the fiscal year 1910:

> Observations of sun, moon, planets, reference stars, and certain clock stars of Newcomb's list, so made as to be reduced fundamentally as well as differentially. The sun, moon, and inferior planets to be observed every day when possible, except Sundays and holidays, when the sun and planets may be omitted, and also the moon when it culminates between 8 a. m. and 5 p. m. The superior planets to be observed at least 15 times when culminating between 2 a. m. and 10 p. m., the observations to be distributed with approximate symmetry with respect to the date of opposition. Mars to be observed 20 times between 3 a. m. and 9 p. m. Necessary observations for investigating instrument to be continued.

During the year observations have been made with screens for personal equation for magnitude, of zenith stars in reversed positions of the observer's body for bisection errors and errors due to direction of motion, and of reflected stars in zenith distance for flexure determination. The flexure has also been determined by the use of the horizontal and vertical collimators. Various bisection errors of the observers have been investigated by means of reversing prism eyepieces. The pivot irregularities have been measured by means of an improved axial microscope, and it has been shown that they are probably much smaller than the previous measures have indicated.

The division errors of 20 lines of the circle were redetermined and compared with the previous values. In general the agreement was fairly good, but in some instances there seemed to be evidence of change.

In January a determination of the micrometer screw value at low temperature was made.

The instrument was used clamp west until May 1, 1909, and clamp east since that date. The number of observations is as follows:

Standard stars	3,643
Screen stars	393
Zenith stars	339
Reflected stars	134
Sun	171
Moon	138
Mercury	75
Venus	101
Jupiter	15
Saturn	15
Uranus	14
Neptune	16
Total	5,054

The apparent declinations, except corrections for division errors, flexure, and variation of latitude, are completed to August, 1908, and nearly completed to January, 1909. In right ascension the clock corrections have been applied to November, 1906, and they are adopted and ready for application to April, 1908.

THE NEW CLOCK VAULT.

The work of constructing this vault has proceeded to completion. It was in charge of Prof. F. B. Littell, U. S. Navy. It is not expected to use it at present.

DIVISION OF THE EQUATORIALS.

This division was in charge of Prof. Asaph Hall, U. S. Navy, from July 28, 1908, to the end of the fiscal year. For the first four weeks of the year Prof. W. S. Eichelberger, U. S. Navy, was in charge. The work of the two instruments in this division, as recommended by the Board of 1908 on Plan and Scope of Work, is as follows:

26-inch equatorial.

Observations of satellites and measures of diameters of planets.
Observations for stellar parallax.
Observations of positions of minor planets and comets.
Observations of occultations of stars by moon.
Miscellaneous work such as may be decided upon; as, for example, physical observations of the planets, observations of double stars, nebulæ, clusters, and variable stars at their minima.

12-inch equatorial.

Observations of occultations of stars by the moon.
Observations of comets and the brighter asteroids.
Observations of variable stars.
Visitors.

The work done is as follows: Observations of—

VI satellite of Jupiter	6
Satellites of Saturn	118
Satellites of Uranus	31
Satellite of Neptune	27
20 asteroids	92
2 comets	23

Occultations of stars by moon	22
Diameters of Jupiter	18
Diameters of Neptune	17
Star Bossert 1018 for parallax	9
Arc in Pleiades for micrometer screw	22
Position of instrument	20

On April 29, 1909, the council recommended that the printing of the Equatorial Volume be proceeded with, the copy being then ready for the printer. This volume is No. VI, Naval Observatory, Second Series, and contains the work of the equatorial instruments from 1893 to 1907, inclusive. The printing fund of the Navy Department having been exhausted, it was found to be necessary to let the printing go over until the fiscal year 1910. The work is of high value and should be published as soon as possible.

Three orbits and three ephemerides of asteroids have been computed during the year by Mr. Frederickson.

The observations of the satellites of Uranus have been compared with the data of the Connaissance des Temps. The observations of Neptune's satellite are being worked up, to determine corrections to the elements of the orbit.

As indicated by the summary of observations, considerable attention has been given to the examination of the value of the micrometer screw. A large number of determinations have been made, also, of the position of the instrument and of the different flexures.

The reductions of the observations made on the equatorials, according to the tables issued by the Observatory, are practically up to date.

On June 15 the council recommended the following plan of work for the 26-inch and 12-inch equatorials for the fiscal year 1910:

26-inch equatorial.

Mars: In opposition September 23. Observe satellites and diameters of the planet. Probably some physical measurements like changes in polar cap. August 15–October 15.

Saturn: In opposition October 13. Satellites and diameters of the ball and rings. Of late years it has been the custom to observe the satellites with respect to one another. The following combinations have been made: Mimas-Tethys, Dione-Rhea, Mimas-Rhea, Rhea-Titan, Enceladus-Tethys, Titan-Hyperion, Tethys-Dione, Titan-Japetus, Tethys-Rhea. August 15–November 15.

Uranus: In opposition July 11. Two outer satellites, two inner satellites if possible. Diameter of planet. July 1–August 25, 1909–May 15–July 1, 1910.

Neptune: In opposition January 8. Satellite and diameters of planet. November 1–March 10.

Jupiter: In opposition March 30. Satellite VI, more of faint satellites if possible. Diameters of planet. February 1–May 15.

Halley's comet: To begin a long series as soon as the comet can be observed, observations to extend over, perhaps, six months (January 1–June 30?).

Occultations of stars by the moon.

Eros: (Opposition about May 28, 1910.)

Asteroids: Three to five observations each of such as may be required.

Parallax stars, Double stars, } for which there may be time.

With the above, observations are to be made for value of the micrometer screw, position of the instrument, flexures, etc.

12-inch equatorial.

Occultations of stars by the moon.

Brighter asteroids: Three to five observations each of such as may be required.

Some investigations of instrumental constants, value of micrometer screw, etc.

DIVISION OF THE PRIME VERTICAL.

This instrument has remained in charge of Assistant Astronomer G. A. Hill and has been used steadily in the work of obtaining the aberration and nutation constants and the variation of latitude.

The Board of 1908 on Plan and Scope of Work recommended the work of this instrument as follows:

Observations for variation of latitude.
Observations for aberration and nutation constants.
Observations for declinations of stars.

The work done is as follows:

Observations of 16 stars divided into four equal groups, each group being followed from daylight in the morning through the night until daylight in the evening.

a Lyræ has been observed at every opportunity. Six hundred and twenty-eight observations have been made during the year.

A very thorough examination of the form of the two pivots of the instrument has been made by Mr. Frederick and the observer in charge, using for the purpose an axial microscope. This apparatus consisted of a hand magnifier of 1½-inch focal length, fastened to a tube 39 inches long, and to the latter a filar micrometer was attached. By proper iron support the above was fastened to the south stone pier, on which the instrument rests, the axis of the microscope being placed coincident with the axis of the instrument.

A piece of glass was fastened to the end of the pivot to be measured and on this glass was deposited globules of mercury of about one ten-thousandth of an inch in diameter and then covered with crude balsam. At the opposite pivot an electric lamp was placed, which passed a beam of light axially through the entire instrument. A certain spot of mercury was selected on the plate and then the latter moved so as to bring the spot into practically the center of the field of the micrometer eyepiece.

The microscope used magnifies about 300 diameters and settings on the spot were made at 10° intervals, both in a horizontal and a vertical direction, through a revolution of the instrument.

From a discussion of the measurements made it has been found that the whole range of the quantities secured does not exceed 0.25 of a second of arc and that the range in the level corrections within 15° of the zenith, the part of the pivots resting in the wyes when observations are made, is less than 0.08 of a second of arc.

For the purpose of comparing the variations of latitude obtained at this observatory with those secured at stations in the immediate vicinity, the published results at Philadelphia, Cincinnati, and Gaithersburg, which were secured with the zenith telescope, have been plotted on ruled paper. The latitudes secured with the prime vertical transit instrument have also been plotted thereon for the purpose of studying the curve that will best represent the variation of each.

An inspection of these four curves indicates, in certain parts, that the numerical value of the variation and its phase do not correspond and that the two forms of instruments give different values. The cause for this difference in the variation of latitude between the two forms of instrument has been carefully searched for in the prime vertical observations and it can not be found. The constants used in reducing the prime vertical transit observations have been examined with extreme care. Both pivots upon which the instrument rotates have been measured with precision, and they are both practically true cylinders and an appreciable error of level does not obtain in their form.

The average probable error of a single latitude determination is ±0″.108 for the 16 stars used in obtaining the latitudes.

On June 15 the council recommended the following plan of work for the prime vertical transit:

Observations of four groups of four stars each for variation of latitude and aberration and nutation constants.
Observations for declination of stars.

DIVISION OF THE ALT-AZIMUTH.

This instrument has been in charge of Prof. F. B. Littell, U. S. Navy. As before reported, it was dismounted in July, 1907, and sent to The Warner & Swasey Co. for repairs. It was not returned until April of this year (1909).

The Board of 1908 on Plan and Scope of Work recommended for this instrument as follows:

Observations for absolute or fundamental declinations of the sun and fixed stars.
Observations for atmospheric refraction.

The work done covers the reduction of the 5,400 observations secured from 1903 to 1907, which is nearly complete. The reduction of the 2,500 observations secured before 1903 has been barely started.

The repairs made to the instrument covered the regraduation of the vertical circle on a strip of gold-silver and the regrinding of the pivots. In doing this last the eccentricity of the circle, which had been inconveniently large, was considerably reduced. Examination of the pivots by the spherometer caliper shows them to be very nearly perfect.

New scores were cut and new threads inserted in the microscopes. Besides the two sets of double threads, distant two and a half minutes from each other, used for the regular work, others are provided at distances of two minutes and ten minutes, respectively, for convenience in division error work.

The microscopes do not give as good definition as they should, and it is recommended that new objectives be secured. The power of the microscopes should be higher also.

On June 15 the council recommended the following plan of work for 1910:

Any investigations of instrument which may be necessary for the reduction of past work.

WASHINGTON ZONE CATALOGUE, 1846–1852.

The work of the Washington Zone reductions has been carried on by Prof. W. S. Eichelberger, U. S. Navy.

The reductions of the 7,000 unpublished observations of 1847, 1848, 1851, and 1852 have been completed; the observations have been copied on cards, and the zone corrections have been determined and applied.

The rereduction of all the published transits has been finished.

In order to avoid the introduction of a systematic error due to the motion of the solar system from the date of observation of the zones to that of the Cordoba General Catalogue—the catalogue used for the determination of the zone corrections—the systematic differences between the Cordoba General Catalogue and the Cape Catalogue, 1850, were determined and applied to the Washington observations.

The first five hours of right ascension are ready for the formation of the printer's copy. It is expected to have the entire work ready for the printer before the next annual report.

ROUTINE COMPUTATIONS AND PROOF READING.

This work has been carried on in charge of Miss Lamson, assistant.

It comprises the miscellaneous work in the reduction of observations made with the 9-inch transit circle, the 26-inch equatorial, and the alt-azimuth instrument. Additional work has also been done on the Astronomische-Gesellschaft Zone Catalogue, the Washington Zone Observations, and other incidental work.

PHOTOGRAPHIC WORK.

This work has remained in charge of Assistant G. H. Peters.

The Board of 1908 on Plan and Scope of Work recommended:

Photoheliograph: Photographs of sun at apparent noon.
Photographic telescope: Positions of faint asteroids, faint comets, and miscellaneous objects.
Work in cooperation with 26-inch equatorial.

The following work has been done: Solar photographs taken on one hundred and seventy-seven days with the photoheliograph. The photographic telescope has not been in continuous use, owing to improvements which are now in course. During the year 26 photographs have been made with it, including asteroid fields and comet Morehouse (1908 C.). Mr. Peters is engaged in the labor of constructing a pair of astronomical photographic objectives of about 10 inches aperture and 110 inches focal length, to take the place of the camera now mounted on this telescope.

On June 15 the council recommended the following plan of work for 1910:

Photograph of sun—photoheliograph.
Photographs of asteroids when required—photo telescope.
Work on new lenses—photo telescope, and completion at earliest possible date. Definitive positions of objects photographed when completed.

ASTRONOMISCHE GESELLSCHAFT ZONE CATALOGUE −13° 50′ TO −18° 10′.

This catalogue has been printed and distributed by the Astronomische Gesellschaft of Leipzig, Germany. The catalogue contains 8,824 stars observed by Prof. A. N. Skinner, U. S. Navy (retired) on the 9-inch transit circle, 1894–1905, and forms the fourth volume of the second division of the catalogue of the Astronomische Gesellschaft.

Professor Skinner was engaged until the time of his detachment, June 30, 1909, in preparing material to be used in discussing the proper motions of the stars in this catalogue. All of the observations in other catalogues have been brought up to 1900.0, and the only comparisons still to be made are those with the Washington Zone observations 1846–52. These comparisons can not be made until the work of cataloguing the Washington zones is completed.

DEPARTMENT OF THE NAUTICAL ALMANAC.

The almanac has continued under the direction of Prof. M. Updegraff, U. S. Navy.

The preparation of the American Ephemeris and Nautical Almanac for the year 1912 is nearly complete, and the volume will be ready as soon as the printing can be done. The volume will contain about 700 pages. The following changes in the Ephemeris for 1912 will be made in addition to those mentioned in the last annual report:

1. Provision will be made for correcting the ten-day ephemerides of stars for the short-period terms of the nutation, and the number of stars will be increased from 383, in previous issues of the Ephemeris, to 825, of which 800 are stars whose apparent places are given for every ten days and the remaining 25 consist of 15 northern and 10 southern circumpolar stars whose apparent places are given for the upper transit at Washington for every day in the year.
2. Improved tables will be given of the positions of the brighter satellites of the planets for the convenience of observers.
3. A series of tables for latitude and azimuth from Polaris will be given for the use of navigators, surveyors, and astronomers.
4. The pamphlet entitled "A List of Stars for Navigators," referred to in the last annual report, has proved to be useful for the purpose for which it was intended. It has been prepared for the year 1909, and added as an appendix to the American Nautical Almanac for that year. It will be enlarged and improved as issued for the year 1912.

The preparation and publication of the Ephemeris for 1912 has been delayed in making the numerous changes needed; but it is hoped that the volume will be distributed before the end of the calendar year.

The publication of Volume IX of the Astronomical Papers of the American Ephemeris has been still further delayed by deficiency in the printing fund of the Navy Department.

The work being done by Prof. Simon Newcomb, U. S. Navy (retired), in cooperation with this department, as mentioned in the last annual report, has been completed and is ready for publication as a part of Volume IX of the Astronomical Papers, and is entitled "Researches on the Motion of the Moon." The eclipses for 1912, as published in the American Ephemeris and Nautical Almanac for that year, will be computed with Professor Newcomb's corrections to the position of the moon.

The investigation of the planet Mars has been discontinued temporarily on account of the pressure of routine work.

The records show that the distribution during the past twenty-seven years of the Astronomical Papers of the American Ephemeris, which have been published, has been irregular and unsystematic, resulting in many incomplete sets of that publication in the libraries of this country and of Europe. It has been discovered that there are in the possession of the superintendent of documents, Government Printing Office, and held for sale, a considerable number of these books. On account of lack of storage room and the small demand at the price charged for them, the Public Printer has had under consideration the destruction of these books as useless. In view of these circumstances, information is being collected for the purpose of effecting their distribution to libraries for the completion of sets, and also, in so far as they may be available, to educational institutions and individuals. The superintendent of documents has signified his willingness to transfer the books for that purpose.

There are also available for distribution several hundred copies of a supplement to the American Ephemeris and Nautical Almanac for 1887, bound in cloth, entitled "The Elements of the Four Inner Planets, and the Fundamental Constants of Astronomy," by Simon Newcomb, which is being distributed free as opportunity offers, to libraries and to individuals.

DEPARTMENT OF NAVY COMPASSES.

Lieut. Commander J. S. Doddrige, U. S. Navy, has continued as superintendent of compasses. It is recommended that an assistant be assigned to this department. There is need for a new compass manual. The supply of material for the fleet has been maintained.

DEPARTMENT OF NAUTICAL INSTRUMENTS AND GENERAL STOREKEEPER.

This department was in charge of Assistant E. A. Boeger until September 23, 1908, when he was relieved by Commander B. W. Hodges, U. S. Navy, who remained until May 20, 1909, when he was detached. The department was then taken in charge by Commander E. E. Hayden, U. S. Navy.

Shipments made and stock on hand.

Fiscal year ending June 30—	Number of shipments.	Value.	Value of stock on hand.
1900	136	$40,123.08	$58,574.27
1901	168	43,864.46	64,453.56
1902	252	61,970.29	57,746.96
1903	309	64,345.25	64,006.53
1904	335	71,719.30	91,404.85
1905	395	99,146.80	94,700.77
1906	400	97,713.12	97,129.32
1907	421	115,954.22	101,815.91
1908	506	150,205.84	124,137.36
1909	489	126,821.17	93,592.25

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department has remained in charge of Commander E. E. Hayden, U. S. Navy.

The usual chronometer trial was carried on between January 4 and June 8. The accompanying tabular statements, Tables I and II, give the data.

The usual work of the department in the rating and issue of chronometers and the sending out of the daily telegraphic noon signals proceeded as heretofore. The mean daily error of the noon signal for the year was $0^{s}.05$, and the maximum was $0^{s}.32$.

A special telegraphic time signal was sent out from this observatory at 12–33–34 a. m., December 22, 1908, by special request, to mark the instant when the sun turned north in declination. It was transmitted by telegraph and wireless throughout Alaska, in order to signal the welcome northward motion of the sun and the approaching end of winter.

The New Year's Eve signals were sent out as usual, at midnight, 1, 2, and 3 a. m., to mark the exact instant of the beginning of the new year in each of the great standard time zones of the United States. They were transmitted also as far as Buenos Aires, Australia, Honolulu, Guam, Manila, and Japan.

LIBRARY.

The library has remained in charge of Mr. Wm. D. Horigan, librarian. The space at present available is insufficient and, to remedy this in a measure, it is expected to examine the contents with a view to the withdrawal of matter of no direct value to this institution, and of matter the prospective use of which is highly improbable, and which may be had from the Navy Department and other libraries in this city should necessity arise. The mass of the withdrawals to be considered are publications of departments of the Government.

	Volumes.	Pamphlets.	Total.
Contents of the library July 1, 1908	21,475	4,453	25,928
Accessions	475	96	571
Contents July 1, 1909	21,950	4,549	26,499

Of the accessions, 360 were received as exchanges and 211 were purchased. There were distributed 1,151 copies of the various publications of the observatory.

The routine work is up to date.

BUILDINGS, GROUNDS, AND ROADS.

The buildings require painting and repairs to roofs, gutters, and other incidental repairs, due to wear and tear.

The roads need extensive repairs and the walks some considerable repairs. Some new walks are necessary. The grounds require much work to put them in good condition, this particularly on the lawns.

All of this work will be commenced with the new fiscal year and will be carried on so far as funds will permit.

During the past fiscal year the following work was done: Laid 400 feet water connection; 500 feet sewer pipe from dormitory; 900 feet underground conduit for electric wires; 500 feet concrete walk; graded hill north of Superintendent's quarters; redressed road from main building; filled in gully on Massachusetts avenue with 10,000 cubic yards earth; made 500 feet new road from north entrance Massachusetts avenue; laid 900 feet of gutters and 300 feet of 12-inch sewer pipe to drain new road; graded southeast of barns; filled an unused well.

In the matter of the property lying within the observatory circle not yet acquired by the Government, there are two pieces, one of 1.732 acres belonging to the Normanstone property, and the other of

6.764 acres belonging to the District of Columbia and occupied by the Industrial Home School. The condemnation proceedings for the acquirement of the piece of 1.732 acres is yet before the court, but I learn that it is expected to finally pass upon the questions involved in October of this year. Upon the decision of the court will depend what action may be necessary to carry out the provision of the joint resolution of Congress, approved August 1, 1894, looking to the purchase of the property of which this piece forms a part. There is held available in the United States Treasury for the purchase of this piece of land $15,089.18. The transfer of the Industrial Home School property from the District of Columbia to the United States awaits the necessary appropriation by Congress, the sum involved being $184,404, for which I recommend that Congress be asked to make appropriation.

Changes in Personnel.

Name.	Position.	Promoted to—	Date.	Appointed.	Resigned.	Transferred.	Service completed.	Duty.
C. W. Frederick	Assistant at $1,200	Assistant at $1,600	July 1, 1908					Prime vertical.
G. H. Peters	Assistant at $1,400	do	do					Photographer.
Matt Frederickson	Assistant at $1,200	do	do					Equatorial division.
E. D. Tillyer	Assistant at $1,200, Nautical Almanac office.	Assistant at $1,400, Naval Observatory.	do			From Nautical Almanac office.		VI-inch transit circle.
E. A. Lamson	Assistant at $1,200	Assistant at $1,400	do					Computing Division.
R. M. Packard	Assistant at $1,400			Oct. 3, 1908	June 30, 1909			VI-inch transit circle.
Jesse Pawling	Assistant at $1,200					July 1, 1908, miscellaneous computer.		IX-inch transit circle.
John C. Griffin	Stenographer			July 10, 1908	July 20, 1908			Department Chronometers and Time.
S. G. Barton	Assistant at $1,400			July 18, 1908 (temporary).	Sept. 9, 1908			Computing Division.
Bert F. Smith	Stenographer			July 27, 1908				Department Chronometers and Time.
W. M. Smith	Miscellaneous computer.				Sept. 2, 1908			Computing Division.
L. Lindsay	Assistant at $1,000				Sept. 18, 1908			Do.
M. Gundersen	Miscellaneous computer.	Assistant at $1,000	Sept. 23, 1908			July 1, 1909, miscellaneous computer.	June 30, 1909	Do.
H. E. Burton	do			Jan. 19, 1909				Do.
F. F. Harbour	Assistant at $1,000			do				Do.
F. E. Frisby	Miscellaneous computer.			Feb. 16, 1909 (temporary).			May 20, 1909	Do.
J. Robertson	Assistant at $1,600	Assistant at $1,800	July 1, 1908					Almanac.
P. Fisch	Assistant at $1,200					July 1, 1908, assistant at $1,200.		Do.
W. Auhagen	Assistant at $1,600					Nov. 16, 1908		Do.
H. G. Hodgkins	Assistant at $1,400	Assistant at $1,600	Nov. 24, 1908					Do.
A. Snow	Assistant at $1,200	Assistant at $1,400	do					Do.
W. M. Hamilton	Assistant at $1,000	Assistant at $1,200	do					Do.
I. Martin	Piecework computer	Assistant at $1,000	do					Do.
B. J. Sigmund	do			Feb. 6, 1909				Do.
L. Lindsay	do			May 25, 1909				Do.
E. C. Johnson	Copyist, typewriter			July 16, 1908		Oct. 12, 1908, Bureau of Navigation, Navy Department.		Do.
W. A. Meyer	do			Nov. 9, 1908				Do.

lances (specification No. 16 C 1 of A
9.

er than 25 omitted.

	Chronometer-room. (Orientation changed				
10	**68.27**	**68.64**	**68.12**	**68.57**	**67.**
1	**38**	**39**	**49**	**52**	**53**
r. 21 o . 28.	Mar. 28 to Apr. 5.	Apr. 5 to Apr. 12.	Apr. 12 to Apr. 19.	Apr. 19 to Apr. 26.	Apr. to May
s.	*s.*	*s.*	*s.*	*s.*	*s.*
1.76	+0.64	+0.61	+0.53	+0.53	+0.
0.06	−0.67	−0.81	−0.54	−0.69	−0.
0.90	+0.13	+0.01	−0.01	−0.34	−0.
1.90	−1.47	−1.57	−1.70	−1.73	−1.
0.80	+0.60	+0.60	+0.41	+0.39	+0.
1.19	+0.36	+0.16	−0.10	−0.20	−0.
0.13	−1.60	−1.77	−1.69	−1.70	−1.
0.39	−0.63	−0.87	−0.69	−1.10	−1.
0.49	−1.30	−1.40	−1.40	−1.43	−1.
1.44	+0.89	+1.00	+0.53	+0.39	+0.
1.80	+0.77	+0.63	+0.61	+0.69	+0.
0.83	−1.34	−1.33	−1.13	−1.33	−1.
0.03	−1.21	−1.23	−1.31	−1.51	−1.
1.97	+1.60	+1.66	+1.36	+1.56	+1.
0.97	+1.62	+1.27	+1.07	+0.84	+0.
1.49	0.00	+0.34	+0.33	+0.30	−0.
1.35	+0.35	+0.23	+0.02	−0.14	−0.
2.48	+3.09	+2.83	+2.77	+2.61	+2.

Changes in Personnel.

, Wash

er than 2

10 6

1

. 21

o

. 28.

s.
1.67
0.87
1.06
1.91
0.17
1.47
1.89
0.83
1.71
2.81
2.89
0.34
3.41
0.77
1.53
3.00
0.11
1.87
3.53
0.86
1.77
3.69
2.29
1.10
1.37
1.26
2.00
0.74
3.97
0.89
0.07
1.5

, *Washington, D. C., January 4 t*

er than 25 omitted.

	Chronometer room. (Orientation cha			
10	**68.27**	**68.64**	**68.12**	**68.57**
1	**38**	**39**	**49**	**52**
. 21 o . 28.	Mar. 28 to Apr. 5.	Apr. 5 to Apr. 12.	Apr. 12 to Apr. 19.	Apr. 19 to Apr. 26.
s.	*s.*	*s.*	*s.*	*s.*
1.67	−2.30	−2.29	−2.14	−2.36
0.87	−0.53	−0.51	−0.30	−0.43
1.06	+1.06	+1.03	+0.99	+0.94
1.91	+2.29	+2.23	+2.34	+2.14
0.17	−0.04	+0.13	+0.19	+0.31
1.47	−0.89	−0.96	....	....
1.89	−1.51	−1.36	−1.57	−1.74
0.83	+0.09	+0.16	+0.23	0.00
1.71	+0.01	+0.23	....	....
2.81	+2.14	+2.36	+2.56	+2.46
2.89	+1.63	+1.60	+1.43	+1.59
0.34	−0.59	−0.69	−0.74	−0.77
3.41	+1.97	+2.40	+2.10	+1.99
0.77	−0.41	−0.66	−0.70	−0.66
1.53	+1.26	+1.27	+0.96	+0.91
3.00	+1.83	+1.77	+1.59	+1.39
0.11	+0.60	+0.89	....	....
1.87	+0.10	+0.07	+0.03	−0.04
3.53	+1.64	+1.70	+1.57	+1.60
0.86	−1.64	−1.74	−1.81	−1.89
1.77	−2.31	−2.44	−2.89	−2.84
3.69	+1.77	+1.80	+1.63	+1.50
2.29	+0.44	+0.33	+0.37	+0.40
1.10	+0.14	+0.01	−0.13	−0.19
1.37	+1.20	+0.73	+0.34	+0.44
1.26	+0.33	+0.20	+0.24	+0.17
2.00	+2.80	+2.87	+2.30	+2.26
0.74	−2.17	−2.47	−3.14	−2.89
3.97	+3.24	+3.11	+3.49	+3.03
0.89	−0.43	−0.41	−0.59	−0.67
0.01	+0.17	+0.03	−0.21	−0.14
1.54	+0.76	+0.87	+0.61	+0.73

NAVY DEPARTMENT
UNITED STATES NAVAL OBSERVATORY

SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30

1910

GOVERNMENT PRINTING OFFICE
WASHINGTON
1910

SYNOPSIS OF THE REPORT

OF THE

SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1910.

In general it may be stated that good progress has been made, although the failure to complete the investigation of the 6-inch transit circle as expected is the cause of some disappointment. When the instrument shall have been fully investigated, as is expected in the course of a few months, if found fit for fundamental work, meridian work will be pursued with a sufficient force to secure large results, while keeping the reductions up to date.

The present period of restricted number of observations is being utilized to bring up back work and to effect such repairs and changes in the instruments as are needed to-day. Under the several headings following in this report will be found more definite statements of reductions made and of the condition of the different instruments.

The continuance of the operations of the council shows good results, which will improve as the members become accustomed to the consideration of matters in general and realize fully the necessity of painstaking individual examination of matters presented.

While no definite understanding has been arrived at, it seems fitting that mention should be made in this report of the attitude of this institution in respect to the scheme of the International Permanent Committee for the Photographic Execution of the Chart of the Heavens, of which M. Baillaud, of the Paris Observatory, is the president. This may be best shown by the following reply to the committee's communications, sent by the Naval Observatory to M. Baillaud:

> I have already acknowledged the receipt of your letter of August, 1909, together with inclosures, and now acknowledge the further receipt of a package of papers, all pertaining to the proposed plan for the international observation of the stars for use in reducing photographic observations of the photographic chart of the sky.

All of these papers have received the careful consideration of the Council of this Observatory, and I present now the conclusions so far as may be definitely made at this moment in regard to the attitude of this Institution.

It is believed to be impracticable at present to use other than the historical fundamental stars as standards. The list which it is expected will be observed here fundamentally on the meridian circle for several years to come comprises nearly all the important historical fundamental stars. Such additional stars of this class as might be agreed upon by the International Committee might be added to this list without unduly extending it, and this matter will receive careful consideration if the Committee shall deem such additional observations here to be desirable. It is assumed that this might cover the stars in the lists of 343 and 1,069 stars.

The proposition to observe the 1,339 stars of Doctor Backlund's list would so extend the observing list as to postpone the completion of the work here by several years. However, after the standard stars above referred to have been satisfactorily observed and determined, consideration might then be given to the proposition to observe the list proposed by Doctor Backlund. It is the desire of this observatory to cordially cooperate in the work of improving the positions of the historical standard stars.

In regard to the observation of the intermediary stars, it is thought that more definite information should be awaited before deciding what can be done here.

I have the pleasure to acknowledge on behalf of this observatory the action of the Committee in constituting its Superintendent a member of the International Committee.

Before making any agreement as to the proposition in its final shape, its terms will be submitted to the Navy Department for its sanction, as required by article 12 of the regulations for the government of this observatory.

It has long been contemplated to assemble as a museum the instruments no longer in use, some of which have been packed away for fifty years. Opportunity offering to carry out this plan, the dome room on the second floor of the main building has been utilized for this purpose. The following instruments are already set up in whole or in part, or are about to be set up, wooden piers being provided as necessary:

One mural circle, made by Troughton & Sims, of London, in 1843.

One refraction circle, made by Ertel & Son, of Munich, in 1846.

One meridian circle, made by Repsold & Co., of Hamburg, in 1850.

One 5-inch equatorial, made by A. Clark & Son, of Cambridgeport, Mass., for observing the transit of Venus in 1874.

One coelostat, made by A. Clark & Son, of Cambridgeport, Mass., for observing the transit of Venus in 1874.

One coelostat, made by Wm. Gaertner, of Chicago, for the solar eclipse of 1905.

One universal instrument, made by Ertel & Son, of Munich, in 1846.

One surveyor's transit, made by Richard Patten & Son, of Baltimore.

One dip circle, made by Kent, of London.

One stellar compass and great circle course projector, invented by Captain Lawless.

One recording inclinometer, invented by Lieut. W. E. Edge, R. N.

One patent compass, invented by J. Peichl.

One compass, made by Elliott Brothers, of London.

One magnetometer, made by Elliott Brothers, of London.

One electric chronograph and clock, invented by Prof. John Locke in 1846

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

THE DIVISION OF THE 6-INCH TRANSIT CIRCLE.

This division was in charge of Prof. M. Updegraff, U. S. Navy, until June 16, 1910, when it was turned over to the charge of Prof. F. B. Littell, U. S. Navy, and remains in his charge.

The recommendation of the board of 1908 on plan and scope of work in regard to this instrument, mentioned in last year's report, has been followed, and it is expected that by the end of this calendar year will have been complied with.

The investigation of the microscope micrometer screws has not been continued, but this will be accomplished at a convenient moment in the near future.

During the year the division errors of the degree lines of circle A have been determined at a high temperature in summer and at a lower temperature in the winter and spring. The results of the two series of measures agree fairly well, the average probable error of the mean of the two determinations of each 5° line being 0″.046 and of the mean of the intermediate degree lines 0″.069. In addition, the division errors of the 5° lines of circle B were determined, and of the 10′ lines for 13 scattered arcs of 1° on circle A, and the 2′ lines for two arcs of 20′ on circle A. The errors of the 2′ lines are periodic in character with a period of 10′ and an amplitude of about 1″.1.

During the year observations for right ascension and declination have been made on selected lists of standard stars, and also observations of stars have been made by reflection for determining the flexure of the telescope, and with screens to determine the personal equations of the observers due to star magnitude. The horizontal flexure has also been determined by the use of the collimators. This flexure is small, probably not more than 0″.1. The vertical or cosine flexure is of about the same magnitude.

In addition to the three lists of stars observed with the 6-inch transit circle during the preceding year, there were three additional lists observed during the year ending June 30, 1910. The observations were made in both clamps, and one of the lists, comprising 13 stars, was observed direct and reflected. In addition to the discussion of the observations already made, it is proposed to make a further series of test observations before beginning regular work. This series will comprise observations on 30 stars, well scattered in zenith distance, using a reversing prism to eliminate the effects of certain personal errors, observing in both clamps, direct and reflected, and with the eye end and objective end interchanged. It is expected that the series can be secured and the results reduced by the early part of 1911.

The number of observations made during the year is as follows:

Circumpolar stars	395
Equatorial stars	1,454
Inclination stars	57
Direct and reflected stars	106
Screen stars	229
Personal equation stars	241
Total	2,482
Collimation constant	206
Level constant	229
Azimuth constant	339
Nadir constant	224
Runs of microscopes	38
Total	1,036

The reductions of the observations are nearly up to date.

A series of axial collimator measures was made in March, and the results, while differing somewhat from those obtained from the previous measures, indicate that the irregularities of the pivots are very small.

The circle flexures have been measured and the results are $0''.08 \sin(\theta+70°)$ for circle A and $0''.05 \sin(\theta+20°)$ for circle B, where θ is the reading of the circle under the first microscope.

The following new apparatus has been obtained during the year: Three new level tubes of approximately 1,800 feet radius, from A. Pessler, Freiberg; two new eyepieces of 0.35 inch (9 mm.) and 0.55 inch (14 mm.) equivalent focal lengths, giving powers of 126 and 202 diameters, respectively, from Steinheil, Munich; reversing prism eyepieces for the telescope and north collimator, from J. A. Brashear, Pittsburg; and a new observing chair, after the Repsold pattern, with certain improvements, made at the navy-yard, Washington.

For the fiscal year 1911 it is designed to carry on and conclude the investigation of the instrument and if it is declared fit for fundamental work to proceed with that work.

THE CLOCK VAULT.

This vault was in charge of Prof. M. Updegraff, U. S. Navy, until June 16, 1910, when it was turned over to the charge of Prof. F. B. Littell, U. S. Navy. Mr. John C. Hammond, assistant astronomer, has been in immediate charge.

The following clocks have been used as standards during the year: Riefler No. 151 until August 26; Riefler No. 70 from August 26 to March 9; and Riefler No. 151 from March 9 to June 30.

There has been considerable trouble with leakage of air into the glass cases of the clocks, due to deterioration of the cement in the joints. The joints have been recemented and are now air-tight.

When the regulating devices have worked normally, the monthly variations of temperature in the three clock cases have usually been less than 0°.1 C. The regulating control failed four times during the year, in no case causing a variation of more than 0°.5 C. in the clock cases. An independent thermostat is so arranged as to give warning when the temperature of the vault changes sufficiently to indicate a failure of the automatic control.

Riefler No. 60 was cleaned in July, 1909. Riefler No. 70 stopped on March 9, 1910, on account of failure of the automatic winding apparatus. It was repaired and has since worked satisfactorily.

THE DIVISION OF THE 9-INCH TRANSIT CIRCLE.

This division has been in charge of Prof. F. B. Littell, U. S. Navy. This instrument has been used throughout the year for the determination of the right ascensions and declinations of the sun, moon, planets, clock stars, pole stars, and a few miscellaneous stars. Observations on stars have also been made with screens for determining magnitude corrections in right ascension, with the reversing prism for determining bisection corrections in zenith distance, and by reflection to determine the sine flexure correction in zenith distance. The horizontal flexure was also determined by means of the collimators, and the pivot irregularities have been measured again with the axial microscope. These irregularities are small. In November, 1909, the wyes were resurfaced by Mr. Fecker of the Warner & Swasey Company, and an improvement in the stability of the rotation axis resulted from this change.

The instrument was used clamp east throughout the year and the number of observations secured is as follows:

Clock stars	3,455
Pole stars	916
Miscellaneous stars	64
Screen stars	332
Prism stars	165
Reflected stars	51
Sun	203
Moon	168
Mercury	89
Venus	75
Mars	20
Jupiter	15
Saturn	15
Uranus	17
Neptune	15
Total	5,600
Collimation constant	794
Level constant from nadir	1,120
Azimuth constant from two marks	1,115
Nadir	1,168
Total	4,197

The state of the reduction of these observations will be found under the head of the Division of Reduction of Observations in Arrears.

THE NEW CLOCK VAULT.

This vault has been in charge of Prof. F. B. Littell, U. S. Navy. It has not been in use, and has been without artificial heat during the year. The recorded temperatures vary from 69°.4 F. in August to 45° F. in February. The relative humidity has been high in warm weather. At certain seasons of the year, there is condensation on the ceilings of the corridors, and there has been some leakage of moisture through the walls, from the outside. With artificial heat these conditions could probably be successfully controlled by keeping the temperature at a moderately high point.

THE DIVISION OF THE EQUATORIALS.

This division has been in charge of Prof. Asaph Hall, U. S. Navy, there having been incorporated into this division in September, 1909, the photographic work theretofore conducted separately by Assistant George H. Peters.

Observations were made during the year as follows:

Satellites of Mars	61
VI satellite of Jupiter	3
Satellites of Saturn	63
Satellites of Uranus	19
Satellite of Neptune	36
Diameters of planets	24
Occultations of stars by the moon	39
Seven asteroids	13
Five comets	36
Instrumental constants	12
Arcs for micrometer screw	34
Stars measured for Washington Zone Catalogue	87
Stars identified for Washington Zone Catalogue	39

Of the above observations, 5 of comets were secured with the 12-inch, as well as 12 observations of 6 asteroids, 23 occultations, 1 arc for the micrometer screw, and two determinations of the position of the instrument. Also, 50 stars were measured for the Washington Zone Catalogue, and 20 stars were identified.

A series of observations of Halley's comet was obtained, extending over the period November 9, 1909–June 7, 1910. The remaining part of June, 1910, was cloudy, and in July, observations of the comet had to be given up on account of the accumulation of other work. For two weeks, at the time the comet was nearest the earth, it was necessary to give up entirely both the 26-inch and 12-inch equatorials to the use of visitors. The pressure for admittance to the observatory became so great that three 5-inch equatorials were mounted at the Capitol and two assistants were sent there from the observatory to handle them. Also, two small equatorials were placed on the roof outside the 12-inch dome, and two assistants were detailed to them to show visitors.

It should be noted that the Halley comet committee of the Astronomical and Astrophysical Society of America, through its Secretary, Prof. George C. Comstock, by letter of November 1, 1908, requested this observatory to send a photographic expedition to the Hawaiian Islands to occupy that important station as long as photographs could be secured. This request was not approved by the Navy Department, as such an expedition was deemed to be outside the proper scope of the work of the observatory.

Included in the occultations are those observed during the total eclipse of the moon on November 26, 1909, 8 on the 12-inch equatorial and 10 on the 26-inch.

Various observations made with the equatorials have been published in the Astronomical Journal, including observations of comets, asteroids, satellite VI of Jupiter, and occultations.

The current equatorial reductions are practically completed to date. The discussion is nearly finished of the observations of Neptune's satellite made at the last two oppositions. The measures of Titania and Oberon, outer satellites of Uranus, secured at the last three oppositions, will be discussed during the present calendar year. The observations of the satellites of Mars obtained during the fall of 1909 have been compared with the data of the Connaissance des Temps.

Photographs of the sun were taken at apparent noon on one hundred and fifty-eight days. Solar spots were found on one hundred and forty-seven days. While showing decreased sun-spot activity, compared with the conditions for several years past, the diminution does not correspond to the average condition at this period of the sun-spot cycle.

Volume VI of the Observatory Publications, second series, is now going through the press. In it are included the equatorial observations for the years 1893–1907.

The optical work on the pair of 10-inch astronomical photographic lenses for the photographic telescope has been pushed as rapidly as possible by Mr. George H. Peters, following the curves computed by Mr. E. D. Tillyer. It is expected to have the lenses in use by January 1, 1911. The lens mounts, camera backs, and wrought-iron telescope tubes for the new telescope have been designed by Mr. Peters, and constructed at the Washington Navy-Yard under his supervision.

On account of the work of grinding the new lenses, it has been necessary to omit most of the observations with the photographic telescope, though a number of photographs of Halley's comet were secured.

On Thursday evening of each week visitors have been shown through the 12-inch equatorial, usually by Mr. Peters. Also, a good many special evenings have been given to schools and teachers. A total of 2,250 persons were admitted.

The Clark micrometer II in use with the 26-inch was sent to the Warner & Swasey Company for some improvements, and also the worm screw which drives the large toothed wheel centered on the polar axis was sent to the same firm (the makers of the mounting) to be reground. As is stated in the forthcoming equatorial volume, there is a four-minute periodic error in the driving mechanism. The curve of this error was smoothed out to some extent by the regrinding, but the error still exists, with the same amplitude, approximately.

At this same time new and finer gears were obtained for the slow motion in declination, in order to increase the accuracy of the determinations of parallel, and better illumination was provided for reading the declination circles.

The following instrumental constants of the 26-inch equatorial determined during the period October 20, 1908–June 23, 1910, are exhibited herewith. They may be compared with those of page F 17, Appendix III, Volume IV of the Publications of the United States Naval Observatory, second series, the values there published forming the basis of the 26-inch equatorial reduction tables contained in the appendix. The notation is the same in the two sets of values.

Constants of the 26-inch equatorial.

Date.	Temp.	η	i_1-c	ξ	$\varepsilon \cos \phi$	c	$e \cos \phi$
1908	°.	″	″	″	″	″	″
Oct. 20	48.9 F	+113	−62.8	−48.8	....	....	....
Nov. 17	44.8	....	....	....	+102.2	+123.9	+5.2
1909							
Feb. 6	42.0	+107.8	−59.4	−51.5	....	....	....
14	41.9	....	....	....	+ 96.8	+121.3	+3.0
Mar. 20	40.	+111.8	−62.3	−48.4	+ 86.0	+111.6	−1.7
Apr. 2	42.9	....	....	....	+ 93.3	+118.1	+5.2
3	46.8	+108.2	−60.8	−54.5	....	....	....
6	63.	+109.6	−56.6	−56.2	....	....	....
6	63.0	+110.8	−57.6	−59.4	....	....	....
12	61.8	....	....	....	+ 93.8	+116.2	+5.7
May 5	63.	+111.2	−61.2	−53.9	....	....	....
7	63.3	....	....	....	+ 90.6	+115.0	+1.8
10	59.	+107.6	−62.9	−56.1	+ 95.4	+115.3	+3.9
11	57.	+111.2	−60.2	−53.6	+ 91.5	+114.9	+3.3
June 11	70.5	+109.8	−59.6	−54.0	....	....	....
14	68.7	....	....	....	+ 92.5	+113.0	+4.1
17	72.	....	....	....	+ 91.5	+111.7	+5.2
18	74.8	+110.3	−59.4	−57.6	....	....	....
18	64.	....	....	....	+ 91.5	+112.3	−0.4
19	69.	+109.6	−59.7	−58.5	....	....	....
30	80.	+108.2	−59.8	−56.9	+ 87.1	+110.1	+5.7
July 2	78.2	+110.3	−59.3	−56.0	+ 88.1	+111.0	−0.3
Sept. 2	65.0	+112.6	−60.0	−67.0	....	....	....
6	65.0	....	....	....	+ 86.4	+108.8	+5.1
7	67.6	+112.1	−60.4	−66.1	....	....	....
10	67.7	....	....	....	+ 84.3	+110.2	+5.0
28	57.	+108.1	−57.6	−71.4	+ 93.9	+117.3	+1.9
29	59.5	....	....	....	+ 87.1	+112.6	+5.8
30	62.2	+110.3	−60.9	−69.4	....	....	....
Oct. 28	40.0	....	....	....	+ 98.4	+118.6	+7.0
29	41.	+111.9	−60.8	−62.2	....	....	....
Dec. 1	43.0	+113.1	−60.6	−64.1	+ 89.4	+114.8	+6.1
1910							
Jan. 7	26.	+111.5	−59.8	−63.9	+ 91.8	+116.9	+5.9
25	29.5	+111.2	−60.6	−57.2	+ 84.9	+111.3	+6.8
Mar. 21	46.0	+109.8	−58.8	....	+ 92.1	+114.4	+0.6
23	61.0	+114.9	−60.4	−61.0	....	....	....
25	70.7	+114.4	−62.8	−61.5	+ 92.4	+113.6	−0.1
June 23	83.3	+112.7	−55.9	−69.8	+ 96.3	+117.3	+3.0

Torsion of the tube.

Date.	Temp.	*f*
1909	°	°
June 12	....	+0.010
14	82. F	0.009
20	83.	0.016
20	83.	0.012
23	75.	0.017
23	75.	0.014
Sept. 15	72.4	0.009
15	73.0	0.015
1910		
July 7	75.6	0.015
7	80.8	0.015
8	78.6	0.008
8	85.4	0.016
12	83.6	0.016
13	83.8	0.015
18	75.2	0.014
18	77.8	0.015
Aug. 3	80.1	0.017
7	74.2	0.012
7	74.4	0.015
8	74.0	0.011
8	74.4	+0.016

Mean = +0°.014.

Evidently the 26-inch mounting continues to be very steady and is a good piece of mechanical engineering. On August 21, 1909, one of the doors of the pier was left open and was hit by the elevating floor. This may explain the change in the value of ξ between July 2 and September 2.

THE DIVISION OF THE ALT-AZIMUTH.

This division has been in charge of Prof. F. B. Littell, U. S. Navy. It has not been in use during the year for star observations, but several sets of measures for determining the horizontal flexure by the method of opposed collimators have been made. From a discussion of the results of 15 sets of measures the value $+0''.79$ sin z. d. has been adopted as the correction to observed zenith distances. The probable error of the adopted value is $\pm 0''.063$, indicating considerable accidental error in the separate determinations.

The reduction of the 5,400 observations secured from 1903 to 1907 is practically finished, but the results require further discussion. This is in course. The reduction of the 2,500 observations secured from 1898 to 1903 has been begun, and considerable progress has been made.

In the spring of 1910, after a prolonged spell of very damp weather, it was found that there was a recurrence of the trouble of rust on the steel circle, notwithstanding the fact that it had been copper plated, silver plated, and then painted to protect it from corrosion.

The circle has been returned to the Warner & Swasey Company to be put in good condition and for experiments looking to the securing of better results in this respect. At the same time some minor changes and repairs will be made, the principal item being a provision for obtaining field illumination from a mirror on the objective instead of from a small metallic reflector in the center of the cube as at present.

The matter of securing better microscopes with increased power for reading the circle has been under consideration, but definite action has not yet been taken.

It is expected to have this instrument remounted and ready for work by the end of this calendar year. The project of making the ends of the telescope interchangeable was given much consideration, but it has been abandoned for the present.

THE DIVISION OF THE PRIME VERTICAL.

This division has been in charge of Assistant Astronomer G. A. Hill.

This instrument has been used steadily in making observations in the work of obtaining the aberration and the nutation constants and the variation of latitude. The plan of observing 16 stars divided into 4 groups of 4 stars each has been continued.

A new micrometer for the instrument was procured from the Warner & Swasey Company, of Cleveland, Ohio. To shorten the interval during which a star is passing across a group of threads, the spaces between successive threads have been reduced as small as possible and as now arranged they are only half as wide as they were in the old micrometer. This reduces the time needed for noting transits by the same amount and renders less liable any change in the constants during the interval. The same plan of double sets of threads as obtained in the old micrometer has been adopted in the new one and permits of obtaining transits both direct and by reflection over mercury.

An order has been placed with A. Pessler & Son, of Freiberg, Saxony, for a level tube.

There is now being constructed a west azimuth mark for the instrument.

The observations up to January 1, 1907, are reduced and checked. Those of 1908 are reduced to apparent place. Those of 1909 are not yet copied on sheets.

THE DIVISION OF REDUCTION OF OBSERVATIONS IN ARREARS.

This division is in charge of Prof. W. S. Eichelberger, U. S. Navy, and comprises the duties mentioned in last year's report as being then in charge of Professor Eichelberger and of Miss Lamson. Its duty at present consists in the reduction of back work, proof reading, and a part of the routine reduction of current observations.

The work on the Washington Zone Catalogue, 1846–1852, has been completed with the exception of the identification of a certain few stars upon which both the 26-inch and 12-inch equatorials are engaged. The results of these searches will be entered on the proof sheets. The work will appear in a short time as Volume VII, Publications of the United States Naval Observatory, second series. It was sent to the printer in May, 1910, and 281 pages are now in type. This volume contains the positions of 23,626 stars between 13° 35′ and 45° 25′ south declination, based on 44,500 observations made at the Naval Observatory, 1846–1852.

Volume VI, Publications of the United States Naval Observatory, second series, was sent to the printer in February, 1910, and is in type. It contains the equatorial observations from 1893–1907, both inclusive, and has three appendices:

Appendix I.—Miscellaneous astronomical papers by members of the Naval Observatory staff, including three papers on satellite orbits, one on the solar parallax from observations of Eros, 18 asteroid orbits, and 12 comet orbits.

Appendix II.—Miscellaneous reports on the transit of Mercury, November 10, 1894.

Appendix III.—List of publications issued by the United States Naval Observatory, 1845–1908.

The reduction of the observations made with the 9-inch transit circle, 1903–1910, is well advanced, and it is expected that this work will be ready for the printer in the autumn of 1911. It includes at least 4 observations of each of the stars in Gill's Catalogue of 2,798 Zodiacal Stars, 4 of each of the stars in Hedrick's Zodiacal Catalogue, and 10 of each of the stars in Newcomb's Suggested List of Fundamental Stars. From 30 to 100 or more observations have been secured of each of the clock and azimuth stars. Except for the application of the clock correction after May 1, 1909, the reduction of these observations is completed to May 6, 1910.

The reduction of the sun, moon, and planet observations, about 3,000, for this same period, is in practically the same state.

During the year 27,400 star observations have been copied on cards, including all the observations made up to April, 1907. These observations have been grouped by clamps and observers and the differences determined for pairs of observers, taking the north and south stars separately.

In May the reduction of 2,500 observations made on the alt-azimuth instrument from 1898–1903 was commenced and good progress has been made. These, together with the 5,400 observations, 1903–1907, which have already been reduced, will be ready for the printer in the course of a year.

DEPARTMENT OF THE NAUTICAL ALMANAC.

The Almanac has continued in charge of Prof. M. Updegraff, U. S. Navy.

The expenditure of the piecework fund of $7,000 for pay of computers on piecework for the fiscal year ending June 30, 1910, is as follows:

Name.	Work done.	Compensation.	
Wm. Auhagen	Moon's Long., Lat., and H. P. for 1915	$1,006.25	
	Ephemeris of Mars for 1914	360.00	$1,366.25
G. F. Crawley	Ephemerides of the fixed stars for 1910, 1911, 1912, 1913	706.70	
	Ephemeris of Neptune for 1914	70.00	776.70
E. B. Davis	Ephemeris of the sun for 1914		375.00
A. Doolittle	Ephemerides of the fixed stars for 1910, 1911, 1912, 1913	447.21	
	Elements of occultations of stars for 1912	48.50	495.71
H. B. Evans	Eclipse elements and charts for 1913		234.00
H. B. Hedrick	Ephemeris of Mars for 1913		96.17
H. F. M. Hedrick	Moon's Long., Lat., and H. P. for 1914	143.75	
	Ephemerides of the fixed stars for 1910, 1912	165.60	
	Moon's culminations for 1913	450.00	759.35
Louis Lindsey	Ephemerides of the fixed stars for 1910, 1912, 1913		312.50
J. McWilliam	Ephemerides of the fixed stars for 1910, 1912, 1913	358.23	
	Elements of occultations of stars for 1912	165.34	
	Elements of occultations of stars for 1913	239.00	
	Moon's culminations for 1912	48.50	811.07
G. B. Merriman	Work not yet completed (satellites for 1914)		
F. E. Ross	Ephemeris of Mercury for 1913	611.00	
	Ephemeris of Venus for 1914	415.00	
	Satellite work and moon corrections	131.00	1,157.00
B. J. Sigmund	Ephemerides of the fixed stars for 1910, 1911, 1912, 1913		399.20
T. E. Trott	Ephemerides of the fixed stars for 1910, 1912, 1913		217.05
	Total		7,000.00

The American Ephemeris and Nautical Almanac for the year 1912, enlarged and improved as described in the last two annual reports, was printed and distributed in December, 1909. In this volume the length and breadth of the book are somewhat reduced without reducing the size of the type or the amount of matter on each page, and the quality of the paper used is better. It contains 737 pages as against 603 pages in the volume for the year 1911, the latter including 74½ pages of lunar distance tables which, as stated in the last annual report, are omitted from the volume for 1912. Of the 209 new pages, 40 are due to the placing of 4 instead of 5 ephemerides of ten-day stars on a page, in order to make possible the use of larger type, leaving 169 pages of new matter.

The large number of changes introduced into a single volume of the Ephemeris naturally gave rise to unusual liability to error, and an attempt has been made to meet this contingency by taking unusual care and the adoption of additional safeguards. Thus far nine errors have been discovered and reported.

The preparation of the American Ephemeris and Nautical Almanac for the year 1913 is well advanced, and 525 pages are in type. In addition to the contents of the volume for 1912 this volume will contain ephemerides for physical observations of the sun, moon, and planets. The arrangement will be similar to the volume for 1912. It is expected to print the 1913 volume in one edition, and for 1912 and thereafter not to print the appendix "Star list of the American Ephemeris" nor the appendix "Stars for navigators and polaris tables," nor other appendix to the Ephemeris. The "Star list of the American Ephemeris" will be printed for 1911, but not the "Stars for navigators and polaris tables."

The work entitled "Researches on the Motion of the Moon," mentioned in the last annual report as having been done in cooperation with the late Prof. Simon Newcomb, U. S. Navy, is in type and will be published as part 1 of Volume IX of the Astronomical Papers of the American Ephemeris.

The following publications have been received during the year from the Government Printing Office:

300 American Ephemeris and Nautical Almanac, 1910, second edition.
1,000 American Ephemeris and Nautical Almanac, 1912.
720 American Nautical Almanac, 1910, second edition.
507 American Nautical Almanac, 1912.
1,257 Stars for Navigators, 1910.
999 Star List of the American Ephemeris, 1910.

The distribution of the publications of this office during the year is as follows:

Name of publication.	Naval service.	Other departments.	Superintendent of Documents.	Free distribution.	Total.
American Ephemeris and Nautical Almanac	586	659	230	510	1,985
American Nautical Almanac	601	201	26	9	837
Astronomical Papers	75	....	1	688	764
Stars for Navigators	874	51	200	289	1,414
Star List of American Ephemeris	266	109	50	573	998

These issues comprise volumes of dates from 1890–1912, both inclusive. It will be noted that the Superintendent of Documents, Government Printing Office, received certain volumes for sale. Hereafter books for sale will not be supplied from this observatory.

DEPARTMENT OF NAUTICAL INSTRUMENTS AND GENERAL STOREKEEPER.

The Department of Nautical Instruments and that of the General Storekeeper were both in charge of Commander E. E. Hayden, U. S. Navy, during the entire year.

The work of these departments is increasing in about the same ratio as are the ships which are to be supplied with instruments purchased through this observatory.

DEPARTMENT OF CHRONOMETERS AND TIME SERVICE.

This department has remained in charge of Commander E. E. Hayden, U. S. Navy.

The usual chronometer trial was carried on between January 6 and June 6. The accompanying tabular statements, Tables I and II, give the data.

The usual work of the department in the rating and issue of chronometers and the sending out of the daily telegraphic noon signals proceeded as heretofore. The mean daily error of the noon signal for the year was $0^{s}.05$, and the maximum was $0^{s}.26$.

DEPARTMENT OF NAVY COMPASSES.

Lieut. Commander J. S. Doddridge, U. S. Navy, continued as superintendent of compasses until December 17, 1909, when he was relieved by Lieut. Commander D. W. Blamer, U. S. Navy, who continued in charge through the fiscal year.

The stock of compass material has been maintained at the navy-yards, new ships have been outfitted, and the outfits of old ships kept in repair.

LIBRARY.

The library is in charge of Mr. W. D. Horigan, librarian. The publications comprising the library of the Nautical Almanac and occupying space in the rooms allotted to that department were, during the month of October, taken into the rooms belonging to the library of the Naval Observatory and incorporated with that collection. This transfer consists of 3,998 volumes, of which 3,392 were bound, 563 pamphlets, 2,003 numbers or parts of volumes, five sets of celestial charts, and 25 miscellaneous maps and engravings. Of the bound volumes, 642 were publications of the Nautical Almanac, including six sets of the American Ephemeris and six sets of the Astronomical Papers. All of the books included in the transfer have been catalogued and placed upon the shelves.

The growth of the library has been as follows:

	Volumes.	Pamphlets.	Total.
Contents July 1, 1909	21,950	4,549	26,499
Accessions:			
By purchase	250	4	254
Through exchange	230	52	282
From Nautical Almanac	3,998	563	4,561
Contents July 1, 1910	26,428	5,168	31,596

There were distributed 1,230 copies of the various publications of the observatory.

In March, about 2,300 feet of wooden shelving were constructed in the basement, under the rotunda of the library, to be used for storage of publications of the institution kept for future distribution, and for shelving books needed for the use of the observatory, but for which space was not available in the rotunda and the stack room. The publications of the observatory have been arranged on these shelves, and the work preliminary to the change of location of the other books is in hand.

The withdrawal of matter of no direct value to the institution and of matter the prospective use of which is highly improbable has not yet been undertaken for lack of time. Endeavor will be made to accomplish this in the next fiscal year.

ala
10

eate

0.0

52

ar. 1
to
ar. 2

s
+1.
−1
+2
+4
+5
+2
+
−0
+0
−
+
−
−
+
−

alances (specification No
910.

eater than 25 omitted.

	Chronometer-room. (Or		
0.00	**68.51**	**66.55**	**66.92**
52	**55**	**55**	**51**
ar. 19 to ar. 26.	Mar. 28 to Apr. 4.	Apr. 4 to Apr. 11.	Apr. 11 to Apr. 18.
s.	*s.*	*s.*	*s.*
+1.80	+1.07	+0.97	+0.7
−1.46	−1.11	−1.26	−1.3
+2.34	+0.83	+0.73	+0.50
+4.04	+3.07	+2.96	+2.77
+5.10	+3.47	+3.31	+3.07
+2.06	+0.14	+0.30	−0.11
+1.47	+0.60	+0.40	+0.2
−0.19	+0.20	−0.24	−0.3
+0.87	−0.43	−0.66	−0.8
−1.50	−1.41	−1.11	−1.37
+4.89	+3.51	+3.27	+3.0
−0.47	−2.43	−2.63	−2.9
−0.10	−0.19	−0.23	−0.44
+0.31	−0.89	−1.09	−1.31
−2.17	−2.34	−3.54	−3.8

, T

r th

00

2

. 1

5

. 26

, Washington, D. C., January

r than 25 omitted.

	Chronometer room. (Orientation			
00	**68.51**	**66.55**	**66.92**	**66.94**
2	**55**	**55**	**51**	**56**
. 19 to . 26.	**Mar. 28 to Apr. 4.**	Apr. 4 to Apr. 11.	Apr. 11 to Apr. 18.	Apr. 18 to Apr. 25.
s.	*s.*	*s.*	*s.*	*s.*
.11	....	....	....	....
.36	....	....	....	....
3.16	+2.63	+2.84	+2.50	+2.77
2.47	....	....	....	....
1.39	+0.41	+0.13	+0.16	+0.01
2.00	+1.01	+1.06	+1.09	+0.97
0.03	....	....	....	−0.14
1.39	+1.09	+0.84	+0.73	+0.53
0.03	+0.43	+0.56	+0.61	+0.40
0.31	−0.76	−0.80	−0.79	−1.31
2.33	−1.61	−1.33	−1.39	−1.50
1.69	+0.59	+0.47	+0.37	+0.27
0.10	....	....	....	....
0.71	−0.26	−0.50	−0.57	−0.90
0.41	−1.06	−0.90	−0.80	−0.73
2.29	+1.46	+1.60	+1.74	+1.53
1.26	....	....	....	....
0.51	−1.13	−1.44	−1.37	−1.71
0.36	....	....	....	....
0.57	....	....	....	....
0.07	−1.21	−1.00	−1.09	−1.31
0.63	....	....	....	....
1.40	+0.93	+0.76	+0.57	+0.33
4.47	+3.57	+3.61	+3.47	+3.34
1.19	+0.49	+0.49	+0.31	+0.2
0.57	−0.83	−0.80	−1.19	−1.57
0.11	−0.73	−0.63	−0.69	−0.94
0.54	+0.01	+0.13	+0.54	+0.3
0.03	....	....	....	....
1.10	+0.56	+0.40	+0.51	+0.31
0.56	....	....	....	....
2.26	+0.34	+0.19	+0.16	0.0
0.03	....	....	....	....
0.39	−1.56	−1.80	−1.94	−2.1
0.50	−0.04	−0.24	+0.09	+0.2

NAVY DEPARTMENT
UNITED STATES NAVAL OBSERVATORY

SYNOPSIS OF THE REPORT

OF

THE SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR

THE FISCAL YEAR ENDING JUNE 30

1911

WASHINGTON
1911

UNITED STATES OF AMERICA
GOVERNMENT PRINTING OFFICE

SYNOPSIS OF THE REPORT

OF THE

SUPERINTENDENT OF THE UNITED STATES NAVAL OBSERVATORY

FOR THE

FISCAL YEAR ENDING JUNE 30, 1911.

Commodore T. E. De Witt Veeder, United States Navy (Retired), continued as superintendent.

On July 1, 1910, the Naval Observatory was placed under the Bureau of Navigation.

Again it may be said that good progress has been made for the year just ended.

The following matters may be mentioned here:

1. Volume VI, second series, Equatorial Observations, has been received from the printer and will be issued at once.

Volume VII, second series, Washington Zone Catalogue, has been received from the printer and will be issued at once.

Volume VIII, second series, Alt-azimuth Observations, will be ready for the printer in about six months.

This is all work in arrears. The reductions of observations made with the 9-inch transit circle from 1903 to 1911 are well advanced and it is expected to carry on the work to an early conclusion.

2. The three-years' investigation of the 6-inch transit circle has been concluded, and the instrument has been declared by the council to be fit for fundamental work. Since this instrument has been set up here for about 13 years, and as it has been the subject of the widest differences of opinion among the members of the staff, it is an agreeable duty to announce this declaration, which settles its status.

It has been subjected to extensive and exacting investigation. When the head of the department having it in charge presented for the consideration of the council the data he had secured, the executive committee acting for the council called for further investigation involving about another year's work. When finally the data was secured and the whole considered by the council of six members, its opinion that the instrument was fit for fundamental work was unanimous barring one member. This is made a matter of record for future reference.

I wish also to record that all the members of the executive committee which laid out a part of the work and passed upon the whole of the data, and the head of the department who did the work, pronounced the instrument fit.

The instrument has been entered upon its duty in making its allotment of observations covering our own work and including the scheme of the Permanent International Committee on the Photographic Chart of the Heavens.

3. The 9-inch transit circle has been further investigated and repairs and improvements are in course before again entering it upon its regular duties and its allotment under the scheme of the Permanent International Committee on the Photographic Chart of the Heavens. It is expected that this instrument will be ready for work about September 15, 1911.

4. The alt-azimuth instrument has likewise been repaired and improved, and it is hoped will be ready in the course of six months. Its condition promises excellent work.

5. Congress having allowed $2,500 additional under "Apparatus and instruments," it is designed to procure a new filar micrometer for the 26-inch equatorial. The specifications have been made, and it is expected to be able to place the order in the course of three months.

6. The report for June 30, 1910, mentions the scheme of the Permanent International Committee on the Photographic Chart of the Heavens. This proposition as finally developed in council was submitted to the Navy Department and recommended for approval, and by it approved. The duty of this institution in the premises is best set forth in the letter of the superintendent to the International Committee, which reads as follows:

> I have the honor to acknowledge the receipt of your letters of July 26, 1910, together with inclosures, and of October 26, 1910, with inclosures. These papers have been the subject of careful study by the council of this institution, and it gives me much pleasure to announce to you the program covering the work we have in contemplation. My letter of February 11, 1910, to you lacked definiteness in some particulars. I wish now to inform you that it has been decided—
>
> 1. To attempt the observation of the Backlund stars in addition to the fundamental stars already on our program.
>
> 2. To undertake to secure four observations of each of the intermediary stars observable here.
>
> While this work is undertaken with feelings of the most cordial cooperation in the plans of the committee, and while it is expected to pursue to the end the work about to be undertaken, I am unable to make with you a positive agreement; thus I would leave the institution untied and free to act as future conditions may require.
>
> The receipt of the list of intermediary stars as soon as may be practicable would facilitate the beginning of the work to be undertaken.

7. The activities of the several departments are described hereafter in some detail.

8. A personal-equation apparatus has been designed and is in course of construction.

It may be of interest to state that the museum has been further developed by the introduction of many instruments additional to those mentioned in my last report.

DEPARTMENT OF ASTRONOMICAL OBSERVATIONS.

THE DIVISION OF MERIDIAN INSTRUMENTS.

This division has been in charge of Prof. F. B. Littell, United States Navy.

6-INCH TRANSIT CIRCLE.

The number of observations secured with this instrument during the year is as follows:

Direct and reflected stars	979
Clock stars	315
Pole stars	113
Refraction stars	23
List stars	581
Inclination stars	145
Sun	24
Total	2,180

The number of determinations of instrumental corrections is as follows:

Collimation	262
Level (spirit)	228
Level (nadir)	283
Marks	320
Nadirs	310
Runs	24
Horizontal flexure	21
Total	1,448

In the continuation of the test of the performance of this instrument, a series of observations was made on a list of 30 stars, direct and reflected, clamp east and clamp west, and with eye end and objective end interchanged, using a reversing prism, so that half the observations were taken direct and half reversed.

As a result of a consideration of all the material collected relative to the recent performance of this instrument, it is the opinion of the council that it is fit for fundamental work.

There were found certain systematic differences in right ascension that were developed between the observations clamp east and clamp west, and between direct and reflected observations, and also differences in the deduced azimuths of the marks, clamp east and clamp west, but these can be brought into satisfactory agreement by the assumption of certain flexure terms, principally a variable flexure of the rotation axis amounting to $0^s.025 \cos 2z$. There were also certain differences in results deduced from the reflected observations in declination and those taken direct, which are as yet not explained. It was found that the interchange of ends did not eliminate the sine flexure in zenith distance.

The right ascension and zenith distance micrometer screws and the microscope micrometer screws have been measured for periodic and progressive errors with the Stackpole comparator.

The periodic errors of the right ascension micrometer screw are represented by the formula,

$$-0^s.0002 \cos u \; -0^s.0003 \sin u \; +0^s.0002 \cos 2u \; +0^s.0000 \sin 2u$$

and those of the zenith-distance micrometer screw by the formula,

$$-0''.033 \cos u \; -0''.010 \sin u \; +0''.001 \cos 2u \; +0''.000 \sin 2u.$$

The corresponding coefficients for the microscope micrometer screws do not exceed in any case $0''.08$.

The progressive errors are small.

The pivot irregularities were measured by the axial microscope method, using an improved microscope, and results of great accuracy were obtained. The irregularities were very small and lead to no appreciable errors in the results of observations.

The periodic errors of the two minute lines of circle B have been measured and are found to be practically the same as those of circle A, with a displacement in phase of $4'$ in the $10'$ period.

The device on the self-registering right ascension micrometer for breaking the chronograph circuit when the movable threads are in the unused parts of the field has been replaced by an improved one.

The mirror on the objective for field illumination, which was five-sixteenths inch in diameter, has been replaced by one fifteen-sixteenths inch diameter, and it has been placed on the outside of the objective for convenience in adjusting. It is of silver and is slightly convex.

Two screens have been again attached to the telescope for reducing the brightness of the brighter stars. One reduces the brightness about 5 magnitudes, the other about 3 magnitudes, and the two together about 8 magnitudes. They are operated by the observer from the eye end of the telescope.

The illumination of the microscopes has been changed. There is now a small electric lamp for each microscope. The battery circuit which supplies the current for the lamp is closed by a push button, operated by the foot of the observer, when a microscope is being read.

Two telescopes have been mounted on the north collimator pier for conveniently reading two thermometers, one over the instrument and one near the roof.

In March the counterpoises were changed so that the weight on each pivot was increased to about 20 pounds.

On May 15, 1911, fundamental observations were begun with this instrument on the sun and the following list of stars:

All stars of the American Ephemeris and of Boss's list of 1,059 standard stars which culminate at less than 75° zenith distance.

All stars of the Backlund and Hough lists which culminate at less than 70° zenith distance.

Selected stars at from 75° to 86° zenith distance.

All stars are to be observed approximately an equal number of times in each of four positions: clamp east, position I; clamp west, position I; clamp east, position II; and clamp west, position II, where positions I and II refer to the interchange of eye end and objective end of the telescope.

A sufficient number of reflected observations are to be taken to give material for the determination of the D–R difference.

A hand-driven right ascension micrometer is used for right ascensions, giving 20 transit records for an observation of an equatorial star.

A zenith-distance micrometer screw is used for declinations. Two bisections are taken after the right ascension observation has been completed.

Two divisions on the circle are read under each microscope, and two pairs of double threads, distant 2½ revolutions of the microscope micrometer screw from each other, are used.

A reversing prism is used in all observations, and half of each observation is taken with image direct and half with image reversed.

The instrument is reversed as to clamp at short intervals.

All stars are screened so as to appear to be between the magnitudes 5 and 7.5.

Clock stars are observed in the morning (daylight) and in the evening.

Three observers are employed on this instrument, whose duties will also cover some part of the reductions. The balance of the reductions will be made by the force of miscellaneous computers.

9-INCH TRANSIT CIRCLE.

The number of observations secured with this instrument during the year is as follows:

Clock stars	2,429
Pole stars	369
Miscellaneous stars	8
Sun	158
Moon	121
Mercury	68
Saturn	15
Uranus	9
Neptune	15
Total	3,192

The number of determinations of instrumental corrections is as follows:

Collimation	634
Level by nadir	790
Azimuth	777
Nadir	795
Horizontal flexure by opposed collimators	19
Vertical flexure by vertical collimator and nadir	34
Collimation from vertical collimator and nadir	6
Total	3,055

The difference between the collimation as measured in a horizontal position with the horizontal collimators and in a vertical position with the vertical collimator and nadir was $0^s.005 \pm 0.005$ as determined from six measures.

From an extensive series of measures of the horizontal flexure by the horizontal collimators and of the vertical flexure by the vertical collimator and the nadir in a given position of the graduated circle, and repetition of the same after shifting the circle 180°, it has been found that the greater part of the flexure of this instrument is due to flexure of the circle rather than that of the tube. Applying the results of this investigation to the determinations of flexure made during the past eight years with the circle in different positions on the axis, it is found that all the measures are in satisfactory agreement.

The periodic and progressive errors of the right ascension and zenith-distance micrometer screws and of the eight microscope micrometer screws have been measured with the Stackpole comparator.

The periodic errors of the right ascension micrometer screw are represented by the formula,

$$-0^s.0002 \cos u \; -0^s.0003 \sin u \; +0^s.0000 \cos 2u \; +0^s.0000 \sin 2u$$

and those of the zenith-distance micrometer screw by the formula,

$$-0''.007 \cos u \; +0''.002 \sin u \; +0''.000 \cos 2u \; +0''.001 \sin 2u.$$

Some of the microscope micrometer screws have large errors, but in the way the instrument is used the errors of the microscopes do not seriously affect the observations, inasmuch as the distances measured by the microscope micrometers are usually only a small fraction of a revolution. However, it is intended to secure at once better micrometer screws for these microscopes.

From measures made on the zenith-distance limbs of an artificial sun in the focus of the north-mark lens, with the aid of a reversing prism, the following corrections to an observed declination of the sun's center due to personal errors in observing the limbs were obtained:

	″	″
L	−0.34	±0.023
M	+0.01	±0.021
P	−0.09	±0.023

These quantities are similar in character to the bisection corrections of stars for these observers, but they are numerically smaller.

The adopted bisection corrections to declinations of south stars are as follows:

$''\quad ''$
L −0.59±0.03
M +0.22±0.03
P −0.39±0.03

This instrument was used clamp east until April 11, when observing was discontinued in order to make some minor repairs.

In June the telescope micrometer was sent to Warner & Swasey Co. for a general overhauling. The registering head of the zenith-distance screw was repaired and a protective plate was attached to screen the micrometer from the heat of the observer and to prevent the condensation of his breath from freezing on the head and on the movable plates in cold weather.

It is expected that this instrument will be again put into use in September, on an observing list consisting of the sun, moon, planets, clock stars, and the intermediary stars proposed by the Permanent International Committee on the Photographic Chart of the Heavens. In connection with the latter the new fundamental stars of the list proposed by Director Backlund will also be observed, in accordance with the program of the International Committee.

ALT-AZIMUTH INSTRUMENT.

The instrument has not been in use during the year.

The observations taken between December, 1903, and July, 1907, have been copied for the printer, and those taken from February, 1898, to November, 1903, are nearly ready to be copied for the printer.

The Bausch & Lomb Optical Co. has remodeled the microscopes, furnishing new and improved objectives, oculars with reversing prisms, and screw-focusing adjustments with scales for both objectives and oculars. The magnifying power of the microscopes has been increased from 30 to 48 by adopting oculars of shorter equivalent focus.

The telescope micrometer has been altered by Warner & Swasey Co., so that four readings can be secured on the registering head instead of two, as formerly, and so that the ocular may be moved in R. A. as well as in Z. D. The reticule has also been altered to facilitate taking more bisections of stars during an observation.

The telescope micrometer screw and the microscope micrometer screws are being measured with the Stackpole comparator for periodic and progressive errors.

Three new levels for this instrument have been procured from A. Pessler & Son, Freiberg, Saxony.

PERSONAL-EQUATION APPARATUS.

A personal-equation apparatus, the moving parts of which are to be in the focus of one of the meridian mark lenses, has been planned and the material has been ordered. It is proposed to have one for the 9-inch transit circle and one for the 6-inch transit circle.

By the aid of this apparatus it will be possible to investigate the absolute personal equations of observers, personal equation for magnitude, and personal equation on such objects as the limb of the sun, moon, or planet, under conditions very similar to those of actual observation.

CLOCK VAULT NO. 1.

The temperature control of this clock vault has given satisfactory service, the average monthly range of temperature in the vault when working normally is about 1° F., as shown by the readings of the maximum and minimum thermometers. The variations of temperature in the clock cases are much smaller. The range of the biweekly readings of temperature in the clock case of Reifler No. 151 has been 0°.2 F. for the entire year, with the exceptions noted below.

The following are the only important interruptions to normal conditions in this clock vault:

On January 9 the temperature in the clock cases rose 1°.5 F., due to interruption in control by cutting electric wires in making changes in circuits.

On April 4 the temperature in clock cases fell 3°.5 F., due to interruption in control caused by failure of the gas heater to work properly.

On May 29 the temperature in clock cases rose 0°.7 F., due to relay getting out of adjustment.

On June 10 the temperature in clock cases fell 0°.7 F., due to interruption in electric service caused by an electric storm.

On March 16 the standard clock, Reifler No. 151, dropped 46 seconds. In April it again dropped seconds, and on April 24 it was taken down for cleaning and repairs. Reifler clock No. 60 was substituted as the standard clock.

CLOCK VAULT NO. 2.

This clock vault has never been in use, and has been without artificial heat during the year. The temperature is recorded once a week, and has varied from 68° F. in August to 47° F. in February and March. The condition as to humidity and condensation remains the same as previously reported.

THE DIVISION OF THE EQUATORIALS.

This division, which includes photographic work, has been in charge of Prof. Asaph Hall, United States Navy.

With the various instruments observations were obtained as follows:

26-INCH EQUATORIAL.

VI satellite of Jupiter	5
Satellites of Saturn	98
Satellites of Uranus	29
Satellite of Neptune	39
Occultations	17
One asteroid	2
One comet	8
Instrumental constants	5
Torsion of telescope tube	13
Runs of driving clock for periodic error	26
Arcs for micrometer screws	85
Stars measured for Washington Zone Catalogue	61
Stars identified for Washington Zone Catalogue	19

The observations of the satellites of Saturn made in 1908 have been published in the Astronomical Journal, as well as the observations to December 1, 1910, of occultations, asteroids, comets, and satellite VI of Jupiter.

A discussion has been completed of the observations of Neptune's satellite made in 1908–9 and 1909–10, and of the observations of Titania and Oberon, satellites of Uranus, made in 1908, 1909, 1910. The observations, together with the results of these discussions, have been published in the Astronomical Journal.

For the satellites of Mars, observed in 1909, which were measured in $\Delta\alpha$ and $\Delta\delta$, comparisons of the observations have been made with $\Delta\alpha$ and $\Delta\delta$ computed from the elements of the Connaissance des Temps. The work of obtaining corrections to the assumed elements is nearly completed.

The present mounting for the 26-inch equatorial was installed in 1893 by Warner & Swasey Co. The driving clock has always had a periodic error of exactly 4 minutes, with a range of slightly more than 5 seconds of arc.

Efforts have been made from time to time during these 18 years to correct this error, and latterly the makers were again consulted about it. It was claimed by them that if the clock were run continuously for a long period the wearing smooth of the parts would remove the error. This was tried, and the clock was run continuously for a considerable period, but the error was not appreciably reduced. In August, 1910, a board, consisting of Prof. G. K. Calhoun, United States Navy, and Assistant E. D. Tillyer, of the observatory staff, was appointed to investigate this error.

The first step in the direction of determining the cause of this periodic error was to find out whether the governor rotated at a constant speed. For this purpose the electric synchronizer was used, but only negative results were obtained. It was then decided to test the uniformity of motion of all 4-minute spur gears. The apparatus used for making this test consisted of a small pinion, which, meshing with the gear being tested, made seven revolutions to one revolution of that gear. This pinion was secured to a stiff shaft, which also carried a brass cylinder having a fiber insulating strip on its periphery. An insulated contact point was made to bear on this cylinder, and the breaking of the circuit when the fiber strip passed the contact point was recorded on the chronograph along with the standard Reifler clock. This gave for one complete revolution of the gear being tested seven breaks on the chronograph, which, with a perfect clock train and gears, would be at equal intervals of time. This test showed the final 4-minute spur gear to have a periodic error, but not at all commensurable with the error of the clock. From this it was concluded that the periodic error was due to the four bevel gears, to the worm, or to both combined.

The worm was removed and sent to the navy yard to determine, if possible, the effect of the worm on the error. While at the navy yard it was carefully tested to determine any eccentricity in the threads, any irregularity of the pitch, and whether or not the end thrust bearing was perpendicular to the axis of rotation. The errors due to the above-mentioned causes were found to be so small that it was not considered practicable to correct them. However, the hardened steel end thrust block was carefully reground, since it showed signs of scoring. Some difficulty was found in removing and afterwards cleaning the worm because of the oil which had gummed on it. The particular kind of clock oil used on the worm probably was not suited to the purpose.

The worm was returned from the navy yard, remounted, and records were made, but no appreciable change was found in the periodic error.

It was concluded, therefore, that the error was probably due to more than one cause, but that it could be corrected by introducing an error of opposite sign and with the same amplitude. Two methods were considered for doing this, one by moving the worm back and forth in the direction of its axis by an oblique end thrust bearing, the other by scraping the driving side of the bevel gears, and thus diminishing the angular velocity imparted to the telescope by the teeth meshing at that instant.

It was not considered advisable to use the first method, principally because the correcting error would be a pure sine curve, while the periodic error was not, and therefore could not be entirely neutralized. Another objection to this method existed, in that it necessitated a change in the design of the worm.

It was decided, therefore, to use the second method in an attempt to correct this periodic error of the driving clock. Work was continued upon favorable nights until the 4-minute periodic error was reduced from more than 5 seconds to about eight-tenths of a second of arc as determined by measures upon every tooth, which gave intervals of time of $4\frac{8}{10}$ seconds. Herewith are given three curves showing the error before the beginning of this work, that during the progress of the work, and that after its completion. (See p. 14.)

The gears from the clock to the driving worm, inclusive, have been marked, so that in case of removal at any time they can be replaced in their proper positions.

The regular observations made on the 26-inch equatorial since the completion of the above-mentioned reduction and improvement of the periodic error show that there has been obtained considerable gain in ease of measurement.

During the year there has been noticed a slight endwise play in the declination spindle of the 26-inch equatorial when the instrument is changed from above to below the pier. This end play causes a slight jar, which can be heard but can not be felt on the declination axis.

Correspondence was had with the makers regarding this, and the matter was referred to a board consisting of Prof. G. K. Calhoun, United States Navy, Assistant Astronomer J. C. Hammond, and Assistant E. D. Tillyer.

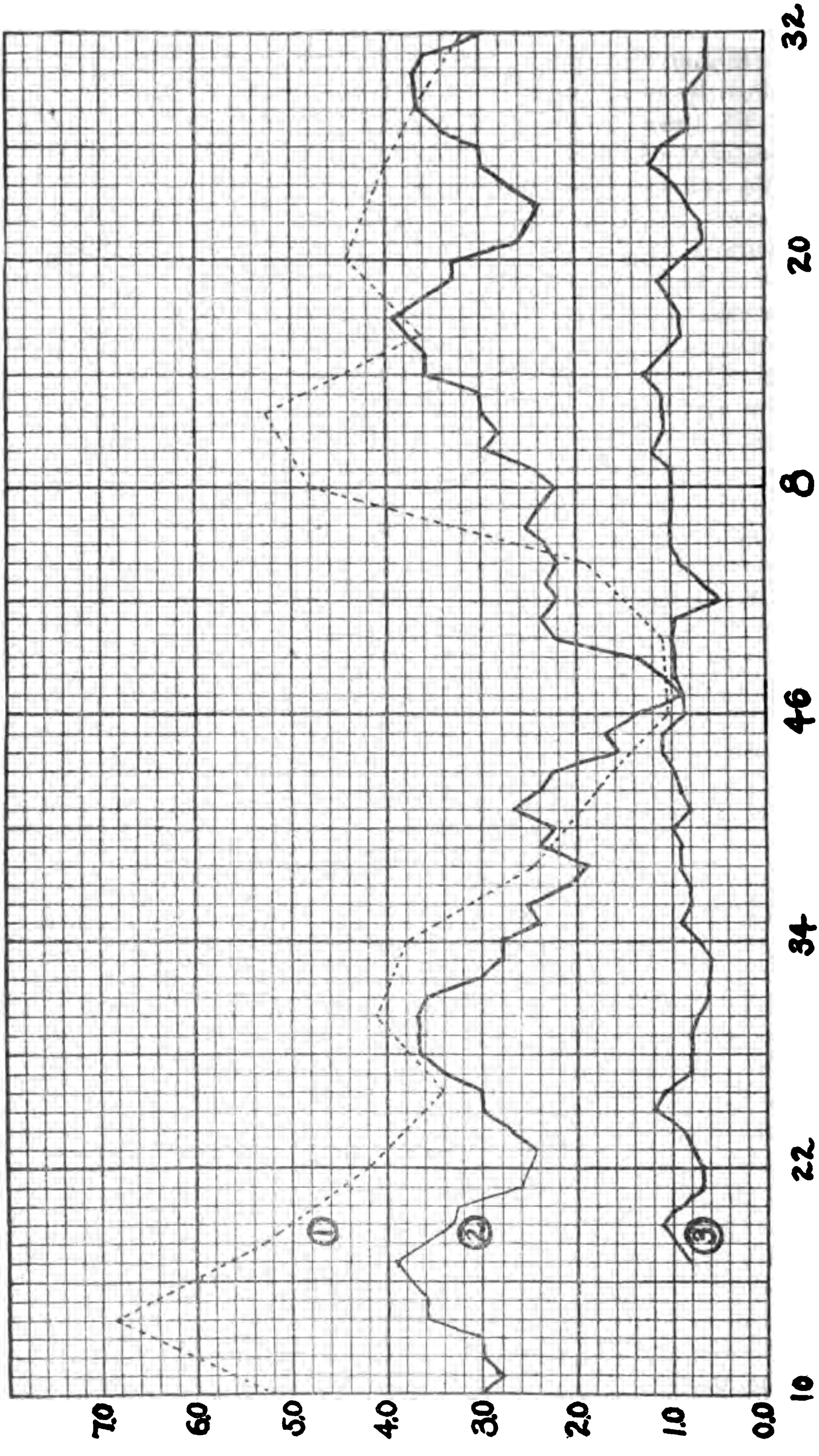
The makers of the instrument state that "it is not intended on this instrument that any adjustment should be provided in the declination spindle for endwise motion, and whatever motion is present is in accordance with the design of the instrument."

From the drawings furnished by the Warner & Swasey Co. it is evident that the weight of the telescope is carried on a set of ball thrust bearings when the instrument is above the pier, and when the instrument is below the pier the weight is carried on a tool-steel collar which bears against the cast-iron declination sleeve.

The collar and declination sleeve have doubtless become worn by long usage, and it is considered advisable to use the instrument above the pier as much as possible, in order to carry the weight on the ball thrust bearings designed for the purpose, and not on the collar, which was designed only for a stop when the telescope is placed below the pier.

In October there was some trouble with the movable distance wires of the Clark micrometer II, which has been in constant use for many years. These wires were broken out several times when the micrometer screw was turned.

A board of survey found that the slide carrying the wires was much worn, and it was necessary, therefore, to have a new slide made. The Warner & Swasey micrometer was used on the 26-inch for about three months while this was being done. This latter micrometer has no arrangement for bright-wire illumination. Owing to this fact and on account of the investigation of the driving clock the usual number



Curve No. 1 made before work commenced.
Curve No. 2 made during progress of work.

Curve No. 3 made after completion of work.
Ordinate, seconds of arc, abscissa, number of teeth.

of observations of the satellites of Saturn was not secured. Also, the satellite of Neptune could not be measured until the return of the Clark micrometer from the instrument makers in the latter part of January.

While the Clark micrometer was being repaired several pairs of double wires were inserted, to be used in measuring faint objects. All the measures of the satellite of Neptune were taken with the double wires. That is, the satellite was placed between a pair of bright wires and the disk of the planet was bisected with a single one. The probable error of a setting is less than when a single bright wire is placed over the satellite. In future measures with the double wires it is expected to use eyepieces provided with reversing prisms. Six new eyepieces were purchased from Steinheil for the 26-inch, three of them being provided with such prisms.

While the Warner & Swasey micrometer was in use on the 26-inch a determination of the screw value was obtained by measuring the difference of declination of the stars A–Z Persei. The value of one revolution was found to be 10″.5758, Hall, and 10″.5744, Burton, for a mean temperature of about 32° F.

In the last appropriation bill the item "Apparatus and instruments" was increased by Congress from $2,000 to $4,500 in order to permit the purchase of a large, modern filar micrometer of the highest grade for the 26-inch equatorial. The observatory staff has given considerable time to the preparation of specifications for this micrometer, which have been completed and forwarded to those instrument makers from whom proposals might be expected.

12-INCH EQUATORIAL.

The following observations have been obtained:

Occultations	24
Four asteroids	11
Two comets	6
Stars measured for Washington Zone Catalogue	24
Arcs for micrometer screw	9
Instrumental constants	1

Considerable improvement has been made in the bright-wire illumination of the 12-inch by Mr. Eppes, so that it is now possible to observe asteroids of a magnitude fainter than could be measured formerly.

On Thursday evening of each week visitors have been shown through the 12-inch, usually by Mr. Peters. Also, a good many special nights have been given to schools and teachers. The total number of persons admitted was 1,746.

PHOTOHELIOGRAPH.

With the photoheliograph photographs of the sun were taken on 148 days. Sun spots were found on 88 days.

The new 10-inch photographic lenses have been completed by Mr. Peters and mounted. They are now in process of adjustment and testing, and both photographic and visual tests show them to be of good figure and rapid. It is expected to begin regular work with them soon.

THE DIVISION OF THE PRIME VERTICAL.

Assistant Astronomer G. A. Hill is in charge of this instrument.

PRIME VERTICAL INSTRUMENT.

The plan of observing four groups of stars with the prime vertical transit instrument has been continued during the year. Observations were made on 120 nights, averaging five hours on each; 576 observations were secured.

The present year closes the eighteenth consecutive one that observations have been made with the instrument. In a recommendation made by the council to the superintendent and approved by him, it was decided to bring the series to a close on December 31, 1912. On that date the observations will have been carried through a complete Metonic cycle, which was the intention at the commencement of the series.

From the commencement in July, 1893, up to July 1, 1911, there has been accumulated 7,507 complete declinations of the stars observed.

With observations to be secured by the time the series is closed and including the discussion of the material, there will be data to make two volumes of about 700 pages each.

The observations made from commencement of the series to the end of 1906 are reduced, checked, entered on printer's copy, and the copy compared with original record and reduction sheets.

The observations made in 1907 are reduced and checked, but have not been entered on printer's copy. Those made in 1908 and 1909 are now being reduced. Those made in 1910 are entered on reduction sheets up to March 1.

During the year an excellent level has been received from A. Pessler & Son, of Freiberg, Saxony.

THE DIVISION OF REDUCTION OF OBSERVATIONS IN ARREARS.

Prof. W. S. Eichelberger, United States Navy, is in charge of this division.

OBSERVATIONS WITH THE 9-INCH TRANSIT CIRCLE.

The observations made with the 9-inch transit circle from September 3, 1903, to April 11, 1911, when work with the instrument was discontinued, have been reduced to mean right ascension and declination 1900.0 for all non-ephemeris stars, to apparent right ascension and declination for all the ephemeris stars, to apparent right ascension and declination for all sun, moon, and planet observations, except that the right ascension observations since April 30, 1909, are reduced to the application of the clock corrections. All the star observations have been collected on cards to October 22, 1910.

Work has been commenced on the preparation of the printer's copy; 140 pages are finished, and 225 more have been commenced. These 365 pages cover the first two years of the work.

OBSERVATIONS WITH THE ALT-AZIMUTH.

The reduction of the 2,500 observations made with the alt-azimuth during 1898–1903 has been completed, and the discordant observations are now being investigated. The 5,000 observations made with this instrument during 1904–1907 have been copied for the printer. These 5,000 observations will occupy 264 pages of an observatory volume.

ROUTINE REDUCTIONS.

Some work has been done in connection with the observations made on the 6-inch transit circle and on the prime vertical.

PRINTING.

The two volumes announced in the last annual report as on the press, Volumes VI and VII, Publications of the United States Naval Observatory, second series, were received at the observatory in June ready for distribution.

DEPARTMENT OF THE NAUTICAL ALMANAC.

Prof. M. Updegraff, United States Navy, continued as director until November 2, 1910, when he was succeeded by Prof. W. S. Eichelberger, United States Navy, who continues in charge.

PIECEWORK FUND.

The expenditure was as follows:

Names.	Work done.	Compensation.	
Wm. Auhagen	Moon's Long., Lat., & Hor. Par. for 1916	$750.00	
	Ephemeris of Mars for 1914	355.00	
	Ephemeris of Uranus for 1914, 1915	156.00	$1,261.00
G. F. Crawley	Ephemerides of the fixed stars for 1911	129.00	
	Star tables, 1914–1920	411.90	540.90
E. B. Davis	Ephemeris of the sun for 1915		750.00
A. Doolittle	Ephemerides of the fixed stars for 1911, 1913, 1914		199.35
H. B. Evans	Eclipse elements and charts for 1914	270.50	
	Transit of Mercury for 1914	23.00	293.50
H. B. Hedrick	Ephemeris of Mars for 1913	18.83	
	Phenomena for 1913	60.00	78.83
H. F. M. Hedrick	Ephemeris of Mars for 1913	157.40	
	Moon culminations for 1914	225.000	382.40
C. S. Lewis	Miscellaneous checking		92.02
L. Lindsey	Ephemerides of the fixed stars for 1914		179.85

Names.	Work done.	Compensation.	
J. McWilliam	Ephemerides of the fixed stars for 1911, 1913	$163.75	
	Star numbers, 1914, 1915	180.00	
	Occultations, 1913, 1914	316.60	$660.35
G. B. Merriman	Ephemerides of the satellites for 1913, 1914		970.00
F. E. Ross	Ephemeris of Mercury for 1914	611.00	
	Ephemeris of Venus for 1915	415.00	
	Special computation on Jupiter's satellites	8.00	
	Tables of correction to Hansen	159.00	
	Correcting proof of Astronomical Papers, Vol. IX, pt. 1	78.00	1,271.00
B. J. Sigmund	Ephemerides of the fixed stars for 1914		36.00
T. E. Trott	Ephemerides of the fixed stars for 1911, 1914		284.80
			7,000.00

AMERICAN EPHEMERIS AND NAUTICAL ALMANAC FOR 1913.

The American Ephemeris and Nautical Almanac for the year 1913 was received from the printer on May 23, 1911. It contains 758 pages, as against 737 pages in the volume for 1912. The principal change introduced into the volume for 1913 is the addition of ephemerides for the physical observations of the sun, moon, Mars, and Jupiter.

The other changes were mainly in the arrangement.

AMERICAN EPHEMERIS AND NAUTICAL ALMANAC FOR 1914.

It is expected to get out this volume this autumn. By January 1, 1913, it is expected to have out the American Ephemeris and Nautical Almanac for 1915 and 1916, making the issue of the last-named three years in advance of the date of issue.

PRINTING.

Prof. Newcomb's "Researches on the Motion of the Moon," mentioned in last year's report, is not yet ready for the press.

The following publications have been received during the year from the Government Printing Office:

160 American Ephemeris and Nautical Almanac, 1910, second edition.
450 American Ephemeris and Nautical Almanac, 1911, second edition.
1,300 American Ephemeris and Nautical Almanac, 1913.
500 American Nautical Almanac, 1911, second edition.
600 American Nautical Almanac, 1913.
1,000 Star List of the American Ephemeris, 1911.

The Navy Department having authorized the distribution of all publications of the Naval Observatory by its librarian under the direction of the superintendent, the Nautical Almanac Office has accordingly been relieved of this duty.

The superintendent of documents, Government Printing Office, is alone authorized to sell observatory publications.

DEPARTMENT OF COMPASSES, CHRONOMETERS, AND OTHER NAUTICAL AND SURVEYING INSTRUMENTS.

On July 5, 1910, Lieut. Commander J. H. Sypher, United States Navy, relieved Lieut. Commander D. W. Blamer, United States Navy, as superintendent of compasses.

On January 30, 1911, the compass office, the department of nautical instruments, and the department of chronometers and time service were combined in one department, under the superintendent of compasses.

CHRONOMETERS.

The usual chronometer trial commenced January 7, 1911, and was completed June 26, 1911. One hundred and eleven chronometers and 16 torpedo-boat watches were entered in this trial. Thirty-six chronometers were new ones offered by the makers, of which 23 were purchased. The remaining 75 belonged to the Government, and were entered for trial after being cleaned and repaired.

The accompanying tabular statement, Tables I and II, give the data for those chronometers and torpedo-boat watches in the trial having trial numbers of less than 25.

Telegraphic time signals were exchanged with the Cape Cruz Casilda survey expedition for the determination of the longitude of reference points at Manzanillo and Cape Casilda, Cuba. For this purpose a direct telegraph line was furnished by the Western Union Telegraph Co. from the observatory to Habana and by the Cuban Government from Habana to Manzanillo and Cape Casilda.

The Reifler sidereal clock at the observatory was used after midnight upon favorable nights for sending a signal which was received on a chronograph at Manzanillo upon which a break circuit chronometer was recording. After a signal of about five minutes' duration had been received the chronometer at Manzanillo was used for sending a signal which was received on a chronograph at the observatory upon which the sidereal clock was recording. Applying clock corrections to both clock and chronometer and making comparisons from both chronograph sheets, the mean of these comparisons determined the difference of time.

These comparisons, for the determination of the difference of time between Washington and Manzanillo, were made by Lieut. G. A. Beall, United States Navy, in charge of the temporary observatory at Manzanillo, Cuba, and are given below:

Comparison by telegraphic time-signal exchanges between Washington and Manzanillo, Cuba.

[Mean date January, 1911.]

	17.5	18.5	19.5	20.5	24.5	25.5	31.5	32.5
	s	s	s	s	s	s	s	s
$\Delta\lambda_1$	14.902	14.862	15.025	14.973	14.884	14.828	14.902	15.039
$\Delta\lambda_2$	14.212	14.338	14.515	14.544	14.337	14.276	14.413	14.549
$\Delta\lambda_3=\frac{1}{2}(\Delta\lambda_1+\Delta\lambda_2)$	14.577	14.600	14.770	14.758	14.611	14.552	14.657	14.794
$\omega_1=\frac{1}{2}(\Delta\lambda_1-\Delta\lambda_2)$	00.345	00.262	00.255	00.215	00.274	00.276	00.245	00.220

$\Delta\lambda=\frac{1}{2n}(\Sigma\Delta\lambda_1+\Sigma\Delta\lambda_2)=14^s.662=$ difference longitude, Manzanillo and Washington.

$(5^h08^m15^s.78)+14^s.662=5^h08^m30^s.442=77°07'36.63''=$ longitude, Manzanillo.

$\omega=\frac{1}{2n}(\Sigma\omega_1)=00^s.261=$ average telegraphic lag of transmission.

$\Delta\lambda_1=$ difference longitude determined at Washington.
$\Delta\lambda_2=$ difference longitude determined at Manzanillo.
$\Delta\lambda_3=$ mean of determinations at Washington and Manzanillo.
$\omega_1=$ telegraphic lag of transmission.

THE LIBRARY.

The library is in charge of Mr. W. D. Horigan, librarian.

BOOKS EXCLUDED FROM THE LIBRARY.

As required by section 67 of the printing act of January 12, 1895, 1,623 volumes of public documents not needed for official use have been withdrawn from the library and have been sent to the superintendent of documents. Of these, 515 belonged to the library and 1,108 were books that had been either turned over to the librarian for disposal or abandoned in the office rooms by persons leaving the observatory. There are still remaining between 1,000 and 1,500 volumes belonging to the library, consisting of duplicates and some departmental publications, which, it is believed, can be sent away without detriment to the work of the observatory. The elimination of such matter from the collection will be continued until it is all disposed of.

CONTENTS OF LIBRARY.

	Volumes.	Pamphlets.	Total.
Contents of library July 1, 1910	26,428	5,168	31,596
Sent to the superintendent of documents	515	....	515
Remainder	25,913	5,168	31,081
Accessions:			
By purchase	155	....	155
Through exchange	335	93	428
Contents July 1, 1911	26,403	5,261	31,664

About 350 feet of wooden shelves were set up in the librarian's room and the anteroom thereto. This relieved the crowded condition of the shelves in the rotunda and the stock room by providing space for the periodicals devoted to physics and chemistry, the sections of geodesy, geology, photography, law, library economy, the miscellaneous section, and all the books on meteorology and magnetism, except the observations which have been shelved in the storeroom under the rotunda.

DISTRIBUTION OF PUBLICATIONS.

On August 19, 1910, the librarian took charge of the receiving, storage, distribution, and accounting for the publications of the Nautical Almanac, and by August 26 all of the publications available for distribution in the almanac storerooms, amounting to 8,751 items, had been counted and removed to the storeroom under the rotunda. (There were also taken over at the same time 840 copies of Nautical Almanac publications known as the reserve. These are to be kept for the future use of the office and are not available for distribution.)

The following publications have been received from the Public Printer:

For the Astronomical Department:	Copies.
Synopsis of the Report of the Superintendent, 1910	1,000
Publications—	
Second series, Volume VI	799
Second series, Volume VI, Appendix 1	1,000
Second series, Volume VI, Appendix 2	1,015
Second series, Volume VI, Appendix 3	1,198
Second series, Volume VII	801
For the Nautical Almanac:	
American Ephemeris, 1910, second edition	160
American Ephemeris, 1911, second edition	450
American Ephemeris, 1913	1,300
American Nautical Almanac, 1911, second edition	500
American Nautical Almanac, 1913	600
Star List of the American Ephemeris, 1911	1,000

There were distributed 891 copies of the publications of the astronomical department and 2,396 copies of the publications of the Nautical Almanac. As required by the department's memorandum of May 17, 1910, a separate report will be submitted showing the number of copies of each publication received and distributed.

BUILDINGS, GROUNDS, AND ROADS.

The buildings are in good order. Painting goes on in good at all seasons except winter. It would be of advantage to per annum man as painter in lieu of one of the laborers. E ment of another sort could be arranged for him when not pai

There was expended under the appropriation "Groun roads" $3,644.33 for labor and $6,279.04 for material, th having been utilized for the following purposes:

Concluded the macadamizing of the roads excepting the western entrance at Wisconsin Avenue; laid 586 running feet crete sidewalk; cleared off damaged trees, stumps, and unde from wooded lands on southern and western sides of the reserv kept in order 40 acres of lawns and parkings; removed snow a and maintained the grounds in good order.

pecification No. 16 C 1 of A

mitted.

hronometer-room (Orientation changed fo

6	68.22	64.02	66.94	72.77
	54	40	49	61
17 24.	Apr. 24 to May 1.	May 1 to May 8.	May 8 to May 15.	May 15 to May 22
	s.	*s.*	*s.*	*s.*
11	+0.29	+0.04	+0.07	−0.0
17	+0.17	+0.13	+0.07	+0.2
83	+0.79	+0.77	+0.99	+0.8
61	+0.44	+0.79	+0.94	+0.9
23	+0.31	+0.30	+0.24	+0.1
24	−0.41	−0.33	−0.20	+0.0
97	−2.11	−2.17	−1.86	−1.5
61	+0.77	+0.46	+0.84	+1.1
13	+1.00	+1.36	+1.49	+1.4
37	+1.63	+1.71	+1.81	+1.8
09	+1.34	+1.51	+1.71	+1.7
29	−2.27	−2.44	−2.40	−2.2
96	+2.06	+2.30	+2.60	+2.6
31	−0.04	+0.20	+0.01	+0.0
94	+0.47	+0.29	+0.34	+0.
77	+1.30	+0.94	+0.76	+0.
79	−0.66	−0.69	−0.73	−0.
36	−0.11	0.00	−0.13	−0.
79	+0.89	+1.09	+1.43	+1.
57	−1.66	−1.66	−1.84	−1.
71	−0.49	−0.37	−1.04	−1.
84	−7.06	−7.44	−7.47	−7.
49	−2.60	−2.54	−2.77	−2.

y,

er th

3

0.

20
57

20
40
01
51
73
83
74
19
20
13
04
26
97

07
33
50
54
07
36
36
33
36
76
36
10
56
30
56
57
36
09
0
6
0
4
9
6
3

y, Washington, D. C., Jan. 7 to June 26

er than 25 omitted.

	Chronometer room. (Orientation changed for pola				
	62.86	63.22	64.02	66.94	72.77
	48	54	40	49	61
3 0.	Apr. 17 to Apr. 24.	Apr. 24 to May 1.	May 1 to May 8.	May 8 to May 15.	May 15 to May 22.
	s.	*s.*	*s.*	*s.*	*s.*
20	−2.50	−2.50	−2.53	−2.47	−2.50
57	+1.33	+1.20	....	....	....
...	....	....	....	....	....
20	....	....	....	....	....
40	....	....	....	....	....
01	0.00	−0.03	+0.29	+0.09	−0.10
51	+0.87	+1.00	+1.03	+1.00	+0.84
73	+0.31	+0.33	+0.36	+0.57	+0.61
83	+1.86	+1.84	....	....	....
74	−2.00	−1.91	−2.11	−1.94	−1.99
19	+0.11	+0.01	....	....	....
20	+0.19	+0.19	+0.44	+0.51	+0.33
13	−1.21	−1.17	−1.50	−1.54	−1.47
04	....	....	....	....	....
26	−0.23	−0.41	−0.31	−0.51	−0.51
97	−3.07	−3.10	−2.97	−3.23	−3.06
...	....	....	....	....	....
07	+1.21	+1.23	+1.27	+1.41	+1.77
33	−0.90	−0.67	−0.61	−0.63	−0.24
50	+0.56	+0.56	+0.80	+0.44	+0.70
54	....	....	....	....	....
07	+1.46	+1.57	+1.51	+1.29	+1.36
66	....	....	....	....	....
36	+1.80	+1.89	+1.54	+1.36	+1.04
33	....	....	....	....	....
36	+1.17	+1.06	+1.01	+0.73	+0.50
76	−3.59	−3.70	−3.26	−3.06	−2.87
36	−2.11	−2.11	....	....	....
10	−0.89	−0.93	−0.89	−1.06	−1.03
56	+1.19	+1.09	+0.87	+0.64	+0.64
30	+0.04	+0.10	+0.17	+0.11	−0.29
56	+2.06	+2.14	+2.29	+2.34	+2.81
57	+1.74	+1.69	+1.59	+1.31	+1.07
36	+4.24	+4.17	+4.09	+3.81	+3.56
09	+1.50	+1.30	+1.51	+1.49	+1.30
0	+0.90	+0.81	+0.77	+0.33	−0.19
36	−0.84	−0.66	−0.81	−0.61	−0.57
0	+1.97	+1.93	+2.04	+2.34	+2.20
4	+0.04	−0.10	+0.01	−0.14	−0.34
9	+0.76	+0.73	+0.94	+1.00	+0.94
26	+2.90	+2.73	+2.31	+2.53	+2.59
3	−0.10	−0.07	+0.10	−0.17	−0.16

APPENDIX NO. 3 TO THE ANNUAL REPORT OF THE
CHIEF OF THE BUREAU OF NAVIGATION, 1912

ANNUAL REPORT OF THE
NAVAL OBSERVATORY

FOR THE

FISCAL YEAR 1912

WASHINGTON
GOVERNMENT PRINTING OFFICE
1912

APPENDIX NO. 3.

REPORT OF SUPERINTENDENT OF NAVAL OBSERVATORY.

Bureau of Navigation,
Washington, D. C., October 30, 1912.

From: Superintendent, Naval Observatory.
To: Bureau of Navigation.

Subject: Report of the superintendent, Naval Observatory, for the fiscal year ending June 30, 1912.

1. Commodore T. E. De Witt Veeder, United States Navy (retired), was relieved as superintendent on October 16, 1911, by Capt. J. L. Jayne, United States Navy.

2. The observatory was represented at the Congrès Internationale des Éphémérides Astronomiques, held at the Observatory of Paris from October 23 to 26, 1911, by Prof. W. S. Eichelberger, United States Navy, director of the Nautical Almanac. The resolutions adopted by the congress were referred to a number of American astronomers, whose opinions were asked concerning certain special points, and they were informed that any suggestions that they might desire to make in connection with the adoption of the resolutions for the American Ephemeris and Nautical Almanac would be gladly received. Eighty-four replies were received, the consensus of opinion being favorable to the resolutions as a whole, but there were differences of opinion about details. With these replies before it the astronomical council, the superintendent presiding, considered Prof. Eichelberger's report with great care. The resulting departmental and congressional action will be found under the heading "Department of the Nautical Almanac."

3. Prof. Eichelberger visited the observatories at Bonn, Berlin, Pulkowa, and Greenwich, under orders from the Navy Department, after the adjournment of the Paris congress, and reported upon his observations for the benefit of this observatory.

4. Assistant G. H. Peters attended the meeting of the committee on asteroids of the Astronomical and Astrophysical Society of America at its meeting in Philadelphia, April 19, 1912, under orders from the Navy Department. As a result of Mr. Peters's report and the consideration given the subject at the observatory, the department has decided not to commit itself to any line of action in connection with asteroids until the completion of the test for accuracy of the photographic telescope which has been constructed at the observatory largely by him. Should this instrument prove as accurate as expected, it would seem desirable to cooperate with the committee in the work of finding asteroids and determining their orbits.

5. In addition to the regular monthly meetings of the astronomical council, it has been called in special session frequently to consider astronomical matters. Assistant Astronomer J. C. Hammond was made a member of it on May 13, 1912.

6. A board was appointed to study computing machines, with special reference to the kind of work done at the observatory and with a view to extending their use if any good results may be gained thereby. A multiplying machine has been bought on the recommendation of this board, and the purchase of other machines is under consideration. It is also intended to test a Hough printing chronograph.

7. The observatory is trying to develop what may be called nautical astronomy. The following quotations from a circular letter issued by the Navy Department, inviting officers to submit suggestions, will explain the nature of this work:

> With regard to nautical astronomy, the purpose is to increase the accuracy and ease with which the position at sea may be determined at any time from observations of heavenly bodies. It is intended that this line of investigation shall seek out new methods of applying astronomical and trigonometrical principles, by use of suitable tables or otherwise; to consider various suggestions that have been advanced in the past, but have not found general application, with a view to determining their practicability; and also to consider combinations of new methods with old ones.
>
> With regard to nautical instruments, it is proposed not only to improve the instruments themselves but also the methods of using them, embracing all kinds of instruments used by navigators.

The results accomplished up to date relate principally to improvements in instruments, as will be seen elsewhere in this report.

8. Advantage was taken of the presence of officers at the observatory for compass instruction to have them instructed in the use of astronomical instruments, particularly transit instruments. This instruction is considered as beneficial to them as navigators and of special value should they be detailed for survey work. One officer received special instruction during the year preliminary to detail on the Honduran survey. Some of the computers have been zealously working at night, without additional pay, to get experience as observers. In order to encourage them, Prof. M. Updegraff, United States Navy, was detailed to give instruction on the south transit instrument.

Department of Astronomical Observations.

Until September 20, 1911, the division of meridian instruments comprised the 9-inch and 6-inch transit circles and the 5-inch alt-azimuth instrument, with Prof. F. B. Littrell, United States Navy, in charge. On that date this division was discontinued and the division of 9-inch transit circle and 5-inch alt-azimuth instrument, and the division of the 6-inch transit circle established.

DIVISION OF 9-INCH TRANSIT CIRCLE AND 5-INCH ALT-AZIMUTH INSTRUMENT.

The personnel of this division consists of Prof. F. B. Littell, United States Navy, in charge, Assistant Astronomer H. R. Morgan, Assistant J. B. Eppes (since Jan. 2, 1912), and Assistant J. Pawling.

9-INCH TRANSIT CIRCLE.

This instrument was not used for observing until February, when regular observations of the sun, moon, planets, clock, and pole stars were resumed. The number of observations secured was as follows:

Clock stars	773
Pole stars	64
Stars for inclination of threads	63
Sun	61
Moon	53
Mercury	31
Neptune	7
Jupiter	14
Total	1,066

The number of determinations of instrumental constants was as follows:

Collimation	306
Level	308
Azimuth	305
Nadir	316
Total	1,235

A new registering head was made for the zenith distance micrometer by the Warner & Swasey Co. The screw, which was not repaired, was remeasured after the work was done, and its periodic errors which were given in the last annual report were found to be unchanged.

Four new microscope micrometers were made by the Warner & Swasey Co. and were received in September. They are provided with two sets of double threads two and one-half revolutions apart. Two of the screws were found to have considerable periodic errors, but these errors were easily reduced by hand grinding with a little rouge at the observatory. The final measures of the screws gave the following coefficients for the periodic errors:

	Cos U.	Sin U.	Cos 2U.	Sin 2U.
	"	"	"	"
I	0.00	+0.02	−0.01	+0.01
II	− .01	− .02	.00	.00
III	.00	− .01	.00	.00
IV	+ .05	+ .02	−.01	− .01

Two new oculars with reversing prisms were secured from C. A. Steinheil Söhne, one for the north collimator and one for the telescope micrometer. The latter gives a magnifying power of 200.

In December a new personal-equation apparatus was set up, the movable parts being at the focus of the north mark lens, the focal length of which is 380 feet. After some experimental work, the apparatus was modified in several essential details, and now seems to be giving excellent results. So far objects other than stars have not been experimented on.

In February a cellular screen for equalizing star magnitudes was attached in front of the object glass of the telescope. It consists of two sets of thin, brass, intermeshing slats at right angles to each other, supported by a ring, which is pivoted so as to turn on an axis inclined 45° to the planes of the slats. The ring can be tilted by turning a rod which extends to the eye end of the telescope and is provided with a graduated head. When the ring is tilted, both sets of slats come into action to cut off the light falling on the objective. The result is a diminution of the apparent magnitude of the star, as observed in the telescope, while at the same time there is a good distribution of light over the objective. For a faint star the spectral images formed are not noticeable with bright field illumination. For bright stars it is desirable to first reduce the apparent magnitude by means of the wire-gauze screens already attached to the instrument and to make the final adjustment by means of the equalizing screen. This screen permits the bringing of all stars, except those fainter than the standard selected, to the same apparent magnitude. The readings of the head may be utilized for determining differences of magnitudes.

A Nicol prism has been secured from Petitdidier, and some experiments have been made, indicating some gain in visibility of the pole stars in daylight by its use.

Among minor changes that have been made may be mentioned an improved setting microscope to facilitate setting the instrument, an improved method of illuminating the microscope heads, and alterations in the observing couch to render it more quickly adjustable to different positions.

In September the pivots were remeasured, the results agreeing fairly well with those of previous measures.

The positions and settings of more than half the intermediary stars of the northern hemisphere have been entered on cards preparatory to the work of observing those stars.

5-INCH ALT-AZIMUTH INSTRUMENT.

The zenith distance micrometer screw was measured with the Stackpole comparator for periodic and progressive errors, and it was found to have irregularities in its motion resulting in abnormal displacements, amounting to more than 1″. Upon investigation this was found to be due to looseness of the bearing head, and to remedy it a new screw with a bearing head of improved design was made by the Warner & Swasey Co. This was received in October. Measures of its periodic errors gave the following coefficients: +0″.004 Cos U +0″.017 Sin U +0″.003 Cos 2U +0″.001 Sin 2U.

The nine microscope micrometer screws were also measured, and several of them were considerably improved by grinding the bearings with a little rouge. The final measures gave the following coefficients for the four microscopes in use on the vertical circle:

	Cos U.	Sin U.	Cos 2U.	Sin 2U.
	″	″	″	″
A......	−0.04	0.00	−0.01	0.00
B......	+ .07	− .01	+ .01	− .02
C......	+ .02	+ .08	.00	.00
D......	− .05	− .05	+ .02	+ .01

A determination of the division errors of the degree lines of the vertical circle by the method of Bruns has been undertaken. The work was planned by Mr. Morgan and executed by Mr. Pawling. All the measures have been made, but the reductions have not been completed.

An investigation of the bisection errors with this instrument has been made with the aid of a reversing prism, using a single thread and bisecting the image of a stationary artificial star. A short list of stars was also observed on several nights with and without a reversing prism for the same purpose.

The observations 1898–1903 have been copied for the printer, and the collected results 1898–1907 are nearly ready for copying.

DIVISION OF 6-INCH TRANSIT CIRCLE.

The personnel of this division consists of Assistant Astronomer J. C. Hammond, in charge, Assistant Matt Frederickson, and Miscellaneous Computer David Rines.

Fundamental observations, which were begun on May 15, 1911, have been continued during the year in accordance with the approved plans.

The number of observations secured is as follows:

Clock stars	2,089
Pole stars, direct	333
Pole stars, reflected	116
Refraction stars	184
List stars	3,853
Inclination stars	473
Direct and reflected stars	91
Sun	165
Total	7,304

The number of determinations of instrumental constants is as follows:

Collimation	883
Level (spirit)	411
Level (nadir)	1,049
Marks	1,009
Nadirs	1,022
Runs	53
Flexure (horizontal)	18
Flexure (vertical)	3
Total	4,448

According to the original program each list star is to be observed 16 times, and on this basis one-eighth of the work has been completed. Three observers were employed, whose duties also covered part of the reductions. The instrument was reversed 29 times and the stellar focus was adjusted 5 times during the year.

In December the trouble which has been experienced for several years in making reflected observations was remedied. The upper course of flooring along the rails which carry the reflecting basin was taken up and it was found that there was contact between the web of each rail and the lower course of flooring in many places. The ends of the boards in this lower course were cut off on both sides of and for the entire length of each rail. The ends of the rails on the north were also supported by two timbers extending from the concrete foundation to the rails and braced to the collimator and instrument piers. Tests showed a great improvement. Walking on the floor or any ordinary movements which the observer on the ladder may make no longer have any effect on the reflected images.

In January the plane mirror (4¼ by 6 inches) for use with the vertical collimator was tested by the Bureau of Standards. Their report states that "the errors of both surfaces are so large as to make a precise description of them valueless." It will be necessary to purchase a new mirror.

A personal-equation machine has been constructed and mounted on the pier of the south mark. With this apparatus, the absolute personal equations of the observers, their magnitude equation and their personal equations on such objects as the limbs of the sun and moon can be determined under conditions similar to those of actual observation.

An apparatus has been constructed to measure the inclination of the zenith distance threads which has hitherto been determined by observations of stars selected for this purpose. This apparatus consists essentially of a pendulum 26 inches long mounted on knife edges and carrying a brass bar 20 inches long. This bar is rigidly fixed to the top of the pendulum rod at right angles to the rod and also to the line joining the knife edges. The bar is pierced near the ends by two small holes to serve as artificial stars, and means are provided to rotate the whole in the plane of the horizon. It is to be mounted on the pier of the south mark and viewed through the lens for this mark. A hole for the reception of the pendulum has been drilled in the top of the mark pier.

CLOCK VAULT NO. 1.

The temperature in this clock vault has been maintained practically constant at 84° F. throughout the year. The range of temperature in the clock cases as shown by weekly readings has been 0.2° F. with the exceptions noted below:

On July 9 the temperature dropped 0.3° F., due to interruption in the electric service caused by a blown fuse.

During a cold period, lasting from January 5 to January 14, considerable trouble was caused by water freezing in the gas main shutting off the supply of gas to the heater. For part of this time the inner vault was kept as nearly as possible at the proper temperature by means of a small electric heater. This heater was not controlled by a thermostat, but was left burning continuously. The maximum drop of temperature during the period was 4° F.

A new gas heater for the vault exactly similar to the old one was installed on March 12.

Riefler clock No. 60 has been used as the standard clock throughout the year. Its rate, which has been kept large in order that the observations of the same star on different nights should come at different points of the break-circuit wheel, has been very satisfactory.

Riefler clock No. 70 was cleaned in November.

Riefler clock No. 151 was unsealed on May 6 in order to adjust the contact. It was immediately resealed.

DIVISION OF THE EQUATORIALS.

The personnel of this division consists of Prof. Asaph Hall, United States Navy, in charge; Assistant George H. Peters; Assistant J. B. Eppes (to Jan. 1, 1912); Assistant H. E. Burton; and Assistant C. B. Watts (from Jan. 2, 1912).

With the various instruments observations were obtained as follows:

26-INCH EQUATORIAL.

VI satellite of Jupiter	5
Satellites of Saturn	107
Satellites of Uranus	29
Satellite of Neptune	45
Satellites of Mars	27
Diameters of planets	25
Occultations of stars by the moon	13
Comets	16
Instrumental constants and position of the instrument	4
Arcs for micrometer screw	40
Positions of comparison stars	4
Asteroids	6

On account of the considerable southern declination of Jupiter it was necessary to look for satellite VI on a good many nights before five observations could be obtained. It is always a rather difficult object in the 26-inch. It is observed like an asteroid, with reference to stars of the Gesellschaft Catalogues.

The satellites of Saturn were combined by pairs according to the program which has been followed for some years at this observatory. The 107 observations include, therefore, the following combinations:

Mimas-Tethys	6
Mimas-Rhea	5
Enceladus-Tethys	11
Tethys-Dione	10
Tethys-Rhea	10
Dione-Rhea	10
Rhea-Titan	25
Titan-Iapetus	24
Titan-Hyperion	6

Whenever possible an eyepiece was used which was provided with a reversing prism.

Of the measures of the satellites of Uranus 8 were of Uranus-Titania, 11 of Uranus-Oberon, 4 of Umbriel-Titania, 4 of Umbriel-Oberon, 1 of Ariel-Oberon, and 1 of Ariel-Titania.

Ariel and Umbriel were too faint to be referred to the planet. It was necessary therefore to place Uranus behind an occulting strip and combine them with Titania or Oberon.

The satellites of Uranus were measured by bisecting the planet with a single wire and placing the satellite between a double wire. In the case of Ariel and Umbriel referred to Titania or Oberon, Ariel and Umbriel were placed between the double wire.

Usually the satellites of Uranus were too faint to be observed with a reversing-prism eyepiece.

The measures of Neptune's satellite were made with a single wire bisecting the disk of the planet and a single wire placed over the satellite. The double wires were not used.

Of the moons of Mars there were obtained 16 observations of Phobos with reference to the planet and 11 observations of Deimos. A pair of fixed wires having a distance apart a trifle less than the diameter of the planet was placed over the disk, being set so that the distances from the limbs to the wires should be equal. Distances of the satellites from the planet were measured in the direction of Mars' axis and perpendicular to that direction, the data for the position of the axis being taken from the British Nautical Almanac.

The outer satellite of Mars was very faint at this opposition. The inner one was not difficult, but could be measured only when its elongation from the planet was considerable.

For the observations of Phobos and Deimos a microscope cover glass was cemented to the eyepiece, so as to come as near as possible to the plane of the threads. Half the cover glass was smoked and Mars was placed behind the smoked portion.

A few measures were made with an eyepiece which had been employed at previous oppositions of Mars, having a semicircle of red glass near the wires with which the planet was covered.

Of the diameters of the planets 17 sets of measures were of Jupiter, 5 of Uranus, and 3 of Neptune.

Of the comets 4 observations were of 1911 b (Kiess), 7 of 1911 c (Brooks), 3 of 1911 f(Quenisset), and 2 of 1911 g (Beliawsky).

One observation was made of (451) Patientia, 2 of (246) Asporina, and 3 of (491) Carina.

Discussions of satellite observations have been completed as follows:

Satellites of Mars, measured in 1909.

Satellite of Neptune, opposition of 1910–11.

Satellites of Uranus, opposition of 1911.

A large modern filar micrometer of the highest grade has been ordered for the 26-inch equatorial from Messrs. C. L. Berger & Sons, of Boston, to be constructed by A. Repsold & Sons, of Hamburg, Germany. This instrument is to be of iron and steel, and is to have a printing device for the registration on a Morse fillet of the readings of the micrometer head.

12-INCH EQUATORIAL.

The following observations have been obtained:

Comets:	
1911 c (Brooks)	1
1911 f (Quenisset)	1
Asteroids:	
1911 (N. J.)	2
451 (Patientia)	1
Occultations of stars by the moon	15
Nova Geminorum:	
Determinations of position	3
Magnitudes	8

On Thursday evening of each week visitors have been shown through the 12-inch by Mr. Peters. Also a good many special nights have been given to schools and teachers. The number of persons admitted was 1,209, on 63 nights.

PHOTOHELIOGRAPH.

Photographs of the sun were taken with the photoheliograph on 136 days. Sun spots were found on 34 days. This is the year of sun spot minimum, which occurred according to our observations in February. During the year most of the spots have been small and evanescent, although several large groups have appeared.

For some months regular use has been made of one of the pair of astronomical photographic lenses of 10 inches aperture and 110 inches focal length, which were completed and mounted last year. One lens has not yet been put in adjustment.

A number of asteroids have been photographed, and the plates are being measured and reduced. It is intended to take up soon the adjustment of the second lens.

DIVISION OF THE PRIME VERTICAL TRANSIT INSTRUMENT.

This instrument has been in charge of Assistant Astronomer George A. Hill.

The prime vertical transit has remained in good order during the past year, and it has not been out of use for a day on account of needed repairs. The apparatus connected with it is also in good order. The series of observations that would cover a Metonic cycle has now been secured, but they will be continued until December 31, 1912, so as not to make a break in the groups being observed.

As stated in the last annual report, it was decided by the council, and approved by the superintendent, to bring this series to a close at the end of 1912. During the year observations were made on 124 nights, and 558 declinations secured.

There has been accumulated since the commencement of the series in 1893, 8,065 observations, and when it is recalled that each star is observed twice in two positions of the instrument, both over the east and the west vertical, the above is the equal of 32,260 observations made with a transit instrument.

Of the above, 1,837 complete declinations of α Lyrae have been obtained, which is without doubt the greatest number of declinations ever obtained of that star by one observer. This gives an average of 96.7 observations per year for the 19 years.

During the year the observations obtained in 1908–9 and 1910 have been completely reduced and checked. The observations are entered on printer's copy up to July 23, 1907. The observations made in 1911 are entered on reduction sheets to August 15.

DIVISION OF REDUCTION OF OBSERVATIONS IN ARREARS.

The division was in charge of Prof. W. S. Eichelberger, United States Navy, until September 20, 1911. Since that time it has been in charge of the executive committee.

The personnel of this division consists of Assistant Eleanor A. Lamson and Miscellaneous Computers Etta M. Eaton, J. T. Du Pree, jr., J. F. Ritt, and L. P. Steele.

REDUCTION OF 9-INCH TRANSIT CIRCLE WORK, 1903–1911.

The positions resulting from the preliminary reduction of these observations have been collected on cards. The declinations have been corrected for division error, variation of latitude, personal bisection errors, flexure, and preliminarily for errors of assumed latitude and constant of refraction.

In addition to the computing involved in the discussions by which the above corrections were evaluated, work has also been done on investigations relative to annual and diurnal periodic variations in the refraction.

About 800 pages of printer's copy of the journal publications of these observations have been completed, covering the period from September 3, 1903, to January 22, 1909.

REDUCTION OF 6-INCH TRANSIT CIRCLE WORK.

The work of this division has consisted in cooperating with the observers assigned to the instrument in reducing recent observations. The reduction of observations from May 15, 1911, to March 17, 1912, has been completed in declination through reduced declination and is well advanced in right ascension. These observations number about 6,000.

REDUCTIONS OF ALT-AZIMUTH WORK.

The declinations resulting from the observations, 1898–1903, have been completed, the results collected on cards, and the printer's copy has been made.

Systematic corrections dependent upon the observer and upon the position of the circle have been applied to the observations, 1898–1907.

REDUCTION OF PRIME VERTICAL WORK.

The reduction of the observations for the years 1907–1910 has been completed.

DEPARTMENT OF THE NAUTICAL ALMANAC.

The Almanac has continued under the direction of Prof. W. S. Eichelberger, United States Navy.

The American Ephemeris and Nautical Almanac for the year 1914 was received from the printer on February 27.

The preparation of the American Ephemeris and Nautical Almanac for the year 1915 is well advanced.

The naval appropriation bill approved August 22, 1912, contained the following:

> The Secretary of the Navy is hereby authorized to arrange for the exchange of data with such foreign almanac offices as he may from time to time deem desirable, with a view to reducing the amount of duplication of work in preparing the different national nautical and astronomical almanacs and increasing the total data which may be of use to navigators and astronomers available for publication in the American Ephemeris and Nautical Almanac: *Provided*, That any such arrangement shall be terminable on one year's notice: *Provided further*, That the work of the Nautical Almanac Office during the continuance of any such arrangement shall be conducted so that in case of emergency the

entire portion of the work intended for the use of navigators may be computed by the force employed by that office, and without any foreign cooperation whatsoever: *Provided further*, That any employee of the Nautical Almanac Office who may be authorized in any annual appropriation bill and whose services in whole or in part can be spared from the duty of preparing for publication the annual volumes of the American Ephemeris and Nautical Almanac may be employed by said office in the duty of improving the tables of the planets, moon, and stars, to be used in preparing for publication the annual volumes of the office: *Provided further*, That section four hundred and thirty-five, Revised Statutes, is hereby repealed.

In accordance with the authority granted by Congress, the department has expressed its willingness to adopt the program of exchanges of data recommended by the International Congress at Paris, October, 1911, with the understanding that the proposed agreement shall be terminable on one year's notice and with the following conditions:

(*a*) That in adopting the resolution, "the ordinary ephemerides of the stars will hereafter be calculated to $0^s.001$ nearly in R. A. to 60° of declination and $0''.01$ nearly in declination, not for every tenth day but for every tenth culmination for the meridian of Greenwich * * *," the department is not committed to the printing of the extra decimals in right ascension and declination, nor to the exclusive use of the Greenwich meridian in the American Ephemeris and Nautical Almanac.

(*b*) With reference to the resolution, "the predictions of the eclipses and occultations will be made with every possible precision," it is understood that the data with regard to eclipses and occultations will be furnished with the same degree of precision as now published in the American Ephemeris and Nautical Almanac.

(*c*) With regard to the meridian of Greenwich and the resolution, "The conference expresses the wish that the adoption of the meridian of Greenwich for all the ephemerides be realized as soon as possible," the department accepts this resolution in spirit but with certain reservations. The American Ephemeris and Nautical Almanac has from the beginning used that meridian for nautical purposes, but on account of the remoteness of the American Continent from it and the fact that the Naval Observatory and other observatories near its meridian are extensive users of the star places published by the American Ephemeris and Nautical Almanac, the department deems it expedient to reserve the right to publish certain ephemerides for the meridian of Washington.

The plan of exchanges will give this office more time to devote to the work of original research and investigation.

It is interesting to note that the congress put its stamp of approval on past work of this office by adopting the list of stars of the Astronomical Papers of the American Ephemeris, Volume VIII, part 3, for the predictions of occultations, and prescribing the tables of Newcomb and Hill for calculations of the positions of the sun and planets for all the ephemerides except the calculations made by the Connaissance des Temps.

It is proposed to make the following changes in the American Ephemeris and Nautical Almanac beginning with the edition of 1916:

In the apparent places of the stars that the right ascension of all stars between +60° and −60° declination be given to $0^s.001$ and that the declination of all stars be given to $0''.01$.

That the mean errors, pages 511–517, edition of 1914, be omitted.

That in the elements for the prediction of occultations, the time of conjunction in right ascension be given in Greenwich mean time.

That in the ephemerides for the physical observations of the sun, moon, and planets and in the satellite data, Greenwich mean time be used.

That the phenomena be published in Greenwich mean time.

The expenditure of the piecework fund of $7,000 for pay of computers on piecework for the fiscal year ending June 30, 1912, is as follows:

Name.	Work done.		Compensation.
Wm. Auhagen	Ephemeris of Neptune for 1915	$65.00	
	Moon's longitude, latitude, and Hor. Par., 1916	425.00	
	Moon's longitude, latitude, and Hor. Par., 1917	1,125.00	$1,615.00
E. B. Davis	Ephemeris of the sun for 1916		750.00
A. Doolittle	Ephemerides of the fixed stars, 1915		150.00
H. B. Evans	Satellite diagrams for 1915	$22.00	
	Eclipse elements and charts for 1915	357.50	
	Special eclipse work	20.50	400.00
H. B. Hedrick	Ephemeris of Jupiter for 1915		140.00
H. F. M. Hedrick	Moon culminations for 1914	225.00	
	Moon culminations for 1915	450.00	675.00
L. Lindsey	Ephemerides of the fixed stars, 1914	323.00	
	Ephemerides of the fixed stars, 1915	175.00	498.00
J. McWilliam	Occultations for 1914	393.65	
	Occultations for 1915	340.40	734.05
G. B. Merriman	Ephemerides of the satellites, 1915		500.00
A. Newton	Occultations for 1915	$83.30	
	Ephemeris of Venus for 1916	7.65	
	Physical observations of the sun, moon, and planets	59.50	
	Secular variations of the planets	35.70	
	Arranging computing blanks	35.70	
	Defective illumination of the moon	22.10	243.95
F. E. Ross	Ephemeris of Mercury for 1915	611.00	
	Ephemeris of Venus for 1915	400.00	
	Reading proof of Astr. Papers, Vol. IX, pt. 1	34.00	1,045.00
T. E. Trott	Ephemerides of the fixed stars, 1915		249.00
	Total		7,000.00

An investigation of the orbits of Saturn's satellites has been commenced during the present year. The work in hand consists of a discussion of the more than 2,000 observations secured at the United States Naval Observatory during the years 1894–1907, and published in Volume VI, Publications of the United States Naval Observatory, second series.

DEPARTMENT OF COMPASSES, CHRONOMETERS, AND OTHER NAUTICAL AND SURVEYING INSTRUMENTS.

PERSONNEL.

On July 31, 1911, Lieut. Commander J. H. Sypher, United States Navy, was relieved as head of the department of compasses, chronometers, and other nautical and surveying instruments, by Lieut. Commander Edward McCauley, jr., United States Navy, at that time in charge of the department of chronometers and time service. The two departments were then combined under one head and called the department of compasses, nautical instruments, and time service, and Lieut. Commander McCauley, placed in charge, with Lieut. Commander C. R. Miller, United States Navy, who reported on July 18, 1911, as assistant and in charge of the compass office.

On September 16, 1911, Prof. G. K. Calhoun, United States Navy, was detached from the time service.

On April 22, 1912, Lieut. Commander C. T. Owens, United States Navy, reported as the relief of Lieut. Commander Miller, who was detached on April 30, 1912.

COMPASS OFFICE.

The stock of articles pertaining to compass outfits has been kept up at the various navy yards sufficient to supply the needs of vessels in service and to equip new vessels delivered during the year, but no large surplus has been accumulated.

The question of developing a better azimuth circle than the present Type III is being studied and different models tried. It is desired to develop an instrument which will be interchangeable on the compass and pelorus and be suitable for taking bearings of distant terrestrial objects and azimuths of stars as well as of the sun.

Two experimental Type VII binnacles and compasses have been tried on the *Florida* and *Utah*, respectively. Both are designed for illumination of the compass card from below. A report has been received from a board of officers appointed by the commander in chief of the United States Atlantic Fleet in regard to the adoption of a standard type for the Navy involving this type of illumination. The various recommendations of the board have been taken up and plans are being prepared at the navy yard, New York, for a standard Type VII binnacle. It is expected that these plans will be completed at an early date.

During the past year the development of the Sperry gyrocompass has continued and many improvements have been made in design and workmanship. A special testing apparatus has been installed at the navy yard, New York, where each set is given a most thorough test before being installed on board ship. The following ships are now supplied with gyrocompass sets: Battleships *Utah*, *North Dakota*, *Delaware*, *Florida*, *Michigan*, and *Arkansas*, and submarines *E-1* and *E-2*. Ten additional gyrocompass sets have been ordered and the first of these sets is now being tested at the navy yard, New York. These will be installed as soon as possible after delivery, on battleships and submarines which have been designated.

In regard to the present status of the gyrocompass as a battle compass, it may be stated that it has come to stay. As is generally the case with a new device there have been many faults and defects to overcome, but these have never been of such a character as to throw doubt upon the ultimate perfection of the instrument, and each set delivered is an improvement over the one preceding it. The specifications for the 10 new sets have been drawn with a special view to remedying the defects existing in the earlier ones, and they will be subjected to the most rigid tests before acceptance. In the meantime the contractors are required during the first year after acceptance of a set to make good any defects and imperfections developing which are clearly due to defective design, material or workmanship, and the earlier sets delivered are therefore now in much more efficient shape than when first installed on board ship.

Recent reports from ships indicate that already this compass is being used for every-day navigation purposes, although always checked by the magnetic compass. In the present state of development, however, it is not considered wise to do away with any part of the magnetic compass equipment of ships having gyrocompasses.

Owing to the development of the gyrocompass the projection compasses are not to be installed on the *Arkansas*, *Wyoming*, and later ships, as was originally planned.

The routine duties of the compass office have been continued during the year, consisting in general of the following:—

(*a*) Compass office tests and inspections of compass parts such as needles, jewels, pivots, and cards, and of magnet correctors.

(*b*) Scrutinizing and filing compass reports from ships.

(*c*) Scrutinizing requisitions and surveys from ships for action pertaining to compass outfits.

(*d*) Scrutinizing numerous reports regarding maneuvering and navigational features of ships.

(*e*) Consulting with representatives of Bureau of Construction and Repair in regard to designs of new ships.

(*f*) Instruction of officers in course of compass instruction.

CHRONOMETERS AND TIME SERVICE.

The usual trial of chronometers and torpedo-boat watches commenced January 9, 1912, and was completed June 17, 1912. One hundred chronometers and 56 torpedo-boat watches were entered in the trial. Fifty chronometers were new ones offered by the makers, of which 33 were recommended for purchase, and 50 torpedo-boat watches, of which 7 were recommended for purchase. The remaining 50 chronometers and 6 torpedo-boat watches belong to the Government and were entered for trial after being cleaned and repaired.

The accompanying tabular statements, Tables I, II, and III, give the data for those chronometers and torpedo-boat watches which attained a trial number of 25 or less in the trial.

For the first time in the history of the observatory some torpedo-boat watches of American manufacture were submitted for trial. These watches failed to pass, but it is worthy of note that the interest of American manufacturers has at last been awakened in this direction.

The department has continued to purchase all chronometers and torpedo-boat watches offered by the makers which pass the required test. The supply of chronometers continues to be adequate, but owing to the small number of torpedo-boat watches which passed the trial the supply of these watches will not be sufficient for the demands of the coming year, especially should emergency arise. Unfortunately there has been no trial of new torpedo-boat watches since 1908. This fact not only did not increase the number of torpedo-boat watches on hand for issue to the service, but apparently gave the makers of such watches no incentive for continuing their manufacture.

After careful investigation and consideration the restriction heretofore imposed on the use of hairsprings made of palladium in the chronometers submitted for trial and purchase has been removed and chronometers having palladium springs will be admitted to the next trial. The specifications have been changed and the makers so informed.

The usual work in the rating and issue of chronometers and torpedo-boat watches and the purchase, trial, and issue of deck clocks, and comparing and stop watches has been proceeded with as heretofore. A new and less expensive form of deck clock, called deck clock No. 3, has been adopted for issue for use in the service under conditions where the higher grades of clocks are not needed.

The daily noon time signal was sent out as usual. The mean daily error of the noon signal for the year was 0.05 second and the maximum error was 0.35 second.

The noon signal has been transmitted by radiotelegraphy to ships at sea since January, 1905, and it is believed that this observatory is the first by over two years to have its time regularly transmitted in this way. With the completion of the Navy's powerful radio station at Arlington it is expected that ships will be able to receive the time signals throughout a very large area of the North Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. It is interesting to note that many jewelers in various parts of the country are expecting to use the radio time signals from the Arlington Station. One writer states that he has received radio signals from the navy yards at Charlestown, Mass., and Portsmouth, N. H., for some months, and "that there are probably at least 10,000 jewelers who will depend on radio signals." Thus the public service rendered by the Navy will find a new and unexpected means of reaching the people.

The observatory is planning the use of radio signals via the Arlington Station for the establishment of differences of longitude.

At the request of the Hydrographic Office, night telegraphic time signals were successfully interchanged with temporary observatories at Habana, Cuba, and at Manzanillo, Cuba, from April 1, 1912, to April 15, 1912, inclusive. These signals were for the establishment of the longitude of those two places, and were transmitted over direct wires and through the courtesy and cooperation of the Western Union Telegraph Co.

NAUTICAL INSTRUMENTS.

The supply of nautical instruments has been kept up to allow for all demands from vessels and from navy yards. These instruments have included those purchased by and furnished from the Naval Observatory for navigation, surveying, and aviation under the Navy Department, for the Lighthouse Service under the Department of Commerce and Labor, and for the Revenue-Cutter Service under the Treasury Department.

Instructions have been issued that nautical instruments usually sent to the Naval Observatory from the navy yards at Mare Island, Puget Sound, and Cavite for repair be repaired, whenever possible, by contract on the Pacific coast. This should effect a considerable saving in shipping charges.

In endeavoring to improve nautical instruments the following has been tried or arrangements have been made for trial:

Several new and improved forms of sextants. The improvements include a form of "endless" tangent screw, electric attachment for reading scale at night, and telescope for night work.

Blish prism, invented by Commander John Blish, United States Navy, retired.

Short base range finders for navigation. A special attachment to standard pelorus for mounting range finder for obtaining simultaneous bearing and range.

Lawless stellar compass; also the development of this instrument by French into one for more accurately solving the spherical triangle.

Lietz sounding machine, with electric motor attached for reeling in.

Universal drafting machine.

Several models of three-arm protractors using transparent material.

A "compass rule," invented by Lieut. A. C. Kail, United States Navy.

Triangles, parallel rulers, protractors of xylonite, or other transparent material.

A three-section parallel ruler.

Barocyclonometer of Father Algué adapted to the North Atlantic Ocean.

Gyroscopic artificial horizon.

Position plotter and course indicator by Capt. R. C. Smith, United States Navy.

Much attention is being given to the selection and inspection of optical instruments.

Directions for use of compensating binnacles are being revised and will be issued at an early date.

A method of compass correction by Lieut. R. A. Koch, United States Navy, is being tried.

GENERAL STOREKEEPER.

Professor of Mathematics M. Updegraff, United States Navy, was general storekeeper up to January 25, 1912, when he was relieved by Lieut. Commander E. McCauley, jr., United States Navy.

The following is a brief summary of the work of this department during the fiscal year:

Value of stock on hand July 1, 1911	$106, 022. 61
Value of instruments, etc., purchased	$24, 010. 24
Value of articles received from navy yards, etc	$39, 734. 33
Value of articles issued	$72, 493. 47
Value of stock on hand June 30, 1912	$97, 273. 71
Number of shipments made	560
Number of instruments, etc., shipped	2, 921

THE LIBRARY.

Mr. W. D. Horigan continued as librarian throughout the year.

Contents of library.

	Volumes.	Pamphlets.	Total.
Contents of library July 1, 1911	26,403	5,261	31,664
Accessions:			
By purchase	116	3	119
Through exchange	167	95	262
Copyright duplicates transferred from Library of Congress	164	2	166
Contents July 1, 1912	26,850	5,361	32,211

DISTRIBUTION OF PUBLICATIONS.

The following publications have been received from the Public Printer:

	Copies.
Synopsis of the Report of the Superintendent, 1911	1,000
American Ephemeris, 1912	300
American Ephemeris, 1914	1,300
American Nautical Almanac, 1912	150
American Nautical Almanac, 1914	600

There were distributed 7,221 copies of the various publications of the institution. Of these, 3,877 were published by the Astronomical Department and 3,344 by the Nautical Almanac.

BUILDINGS, GROUNDS, AND ROADS.

The buildings, grounds, and roads are in good condition. The macadamizing of the road in Observatory Lane was completed. A few trees were blown down by high winds, and some were treated by experts in order to preserve them.

The heating system of the observatory has been carefully studied and changes have been made with a view to producing economy.

During the very cold weather last winter the gas main which leads to the observatory from Wisconsin Avenue was stopped up by reason of water freezing in it at a low point in Observatory Lane. This caused a drop in the temperature in the clock vault, which depends upon gas for heat, and, while the measures taken at the time prevented any serious trouble, as shown elsewhere, a new main has been installed, connecting with the large main in Massachusetts Avenue, to prevent a recurrence of this trouble.

J. L. JAYNE.

TABLE I.—*Tabular statement of data of new American chronometers with steel hairsprings and ordinary balances (Specification No. 18C7, Feb. 19, 1910), United States Naval Observatory, Washington, D. C., Jan. 9 to June 17, 1912.*

[NOTE.—The signs are astronomical, + losing; − gaining. Data of chronometers with trial number greater than 25 omitted.]

Order of merit.	Balance: o=ordinary. v=invar. Hairspring: s=steel.			Trial number.	Point of compensation.			Temperature room trial, mean daily rates. (Orientation of chronometers not changed.)										Chronometer room. (Orientation changed for polarity test, one week on N., S., E., and W.)									
	Temperature, by thermometer........degrees F..							89°.9	85°.0	70°.0	55°.0	50°.2	50°.0	55°.0	70°.0	85°.0	98°.0	67°.2	68°.6	68°.6	68°.4	69°.7	66°.8	69°.6	72°.0	72°.6	70°.1
	Relative humidity, by sling psychrometer, per cent							25	43	36	40	52	52	51	58	48	48	57	53	43	45	49	53	58	57	51	55
					Temperature.	Rate.	Temperature constant.	Jan. 9 to Jan. 16.	Jan. 18 to Jan. 25.	Jan. 27 to Feb. 3.	Feb. 5 to Feb. 12.	Feb. 14 to Feb. 21.	Feb. 21 to Feb. 28.	Mar. 1 to Mar. 8.	Mar. 11 to Mar. 18.	Mar. 20 to Mar. 27.	Mar. 29 to Apr. 5.	Apr. 8 to Apr. 15.	Apr. 15 to Apr. 22.	Apr. 22 to Apr. 29.	Apr. 29 to May 6.	May 6 to May 13.	May 13 to May 20.	May 20 to May 27.	May 27 to June 3.	June 3 to June 10.	June 10 to June 17.
					°	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
1	Bliss..	3109	v. s.	6.74	82.1	+1.35	−.00102	+1.09	+1.44	+1.14	+0.56	+0.29	+0.41	+0.63	+1.26	+1.24	+1.30	+1.41	+1.74	+1.50	+1.46	+1.69	+1.60	+1.89	+1.90	+1.76	+1.53
2	Negus.	2118	o. s.	6.77	41.5	−2.65	+.00011	−2.01	−2.51	−2.64	−2.70	−2.53	−2.50	−2.56	−2.49	−2.36	−2.64	−2.60	−2.59	−2.70	−2.76	−2.84	−2.74	−3.00	−2.99	−3.01	−3.26
3	Negus.	2137	o. s.	6.86	79.8	+0.19	+.00073	+0.30	+0.19	+0.10	+0.57	+1.00	+1.03	+0.70	+0.43	+0.23	+0.09	−0.04	+0.29	+0.04	−0.23	−0.07	−0.09	+0.24	+0.23	+0.06	−0.14
4	Bliss..	3122	v. s.	7.46	85.8	+0.70	−.00080	+0.63	+0.79	+0.74	−0.13	−0.16	−0.03	0.00	+0.26	+0.61	+0.57	+0.57	+0.71	+0.34	+0.36	+0.44	+0.47	+0.54	+0.61	+0.64	+0.57
5	Negus.	2144	o. s.	7.99	190.0	−2.49	−.00004	−2.63	−2.80	−3.20	−3.20	−2.90	−2.91	−3.40	−3.06	−3.16	−3.46	−3.91	−3.96	−4.29	−4.03	−4.03	−4.24	−4.00	−3.87	−3.81	−4.06
6	Bliss..	3094	v. s.	8.94	69.4	−1.22	−.00155	−1.71	−1.64	−1.39	−1.71	−1.61	−1.56	−1.36	−1.04	−1.56	−1.80	−1.09	−1.06	−1.27	−1.27	−1.19	−1.20	−1.10	−1.40	−1.59	−1.69
7	Negus.	2132	o. s.	9.47	76.5	+2.21	+.00095	+2.46	+2.39	+2.59	+2.90	+3.04	+2.57	+2.40	+1.91	+2.16	+2.29	+2.80	+2.40	+2.66	+2.64	+2.54	+2.71	+2.43	+2.50	+2.56	+2.49
8	Bliss..	3116	v. s.	9.62	78.7	−0.72	−.00056	−0.49	−0.86	−0.90	−1.19	−1.29	−1.24	−0.87	−0.63	−0.61	−0.67	−1.16	−0.96	−0.77	−0.76	−0.76	−0.57	−0.37	−0.34	−0.49	−0.43
9	Bliss..	3087	o. s.	10.88	60.2	−1.93	+.00102	−0.71	−1.13	−1.76	−1.93	−1.99	−1.53	−1.86	−1.90	−1.47	−1.39	−2.16	−2.30	−2.17	−2.20	−2.26	−2.00	−1.84	−2.29	−2.40	−2.61
10	Bliss..	3112	v. s.	11.45	66.2	+1.17	−.00159	+0.37	+0.61	+1.00	+0.73	+0.84	+1.11	+1.21	+1.30	+0.61	+0.40	+1.19	+1.56	+1.29	+1.23	+1.43	+1.53	+1.77	+1.67	+1.70	+1.67
11	Bliss..	3088	o. s.	11.49	0.6	−3.33	+.00036	−0.07	−0.67	−1.56	−2.37	−1.97	−1.93	−2.19	−1.67	−0.94	−0.37	−1.49	−1.43	−1.53	−1.66	−1.59	−1.61	−1.63	−1.34	−1.17	−1.34
12	Bliss..	3119	v. s.	12.08	70.8	+0.68	−.00104	+0.47	+0.73	+0.76	+0.51	+0.61	+0.41	+0.33	+0.59	+0.21	+0.94	+1.76	+1.56	+1.07	+1.01	+1.11	+1.17	+1.27	+1.11	+1.11	+0.99
13	Bliss..	3115	v. s.	12.88	58.7	+2.55	−.00105	+1.67	+1.66	+2.00	+2.37	+2.53	+2.53	+2.70	+2.84	+2.00	+1.47	+2.84	+3.17	+3.03	+3.00	+3.23	+3.26	+3.33	+3.21	+3.07	+3.11
14	Bliss..	3113	v. s.	13.15	83.5	+0.14	−.00056	+0.13	+0.26	−0.20	−0.61	−0.37	−0.14	−0.01	+0.29	+0.03	−0.29	+0.47	+0.61	+0.29	−0.23	+0.16	+0.06	+0.13	+0.13	+0.09	+0.07
15	Bliss..	3077	v. s.	13.62	86.1	+1.16	−.00105	+0.66	+1.00	+0.60	−0.04	−0.10	+0.06	+0.33	+1.16	+1.30	+1.21	+1.10	+0.86	+0.89	+1.10	+0.93	+0.69	+1.23	+1.30	+1.26	+1.39
16	Bliss..	3085	o. s.	13.92	64.4	−0.41	+.00158	+1.13	+0.56	−0.29	−0.40	+0.23	+0.26	−0.14	−0.43	−0.04	+0.26	−0.39	−0.44	−0.44	−0.61	−0.89	−0.80	−0.69	−0.79	−0.80	−0.70
17	Negus.	2139	o. s.	14.02	72.5	−0.58	+.00053	+0.17	−0.13	−0.49	−0.13	−0.34	−0.61	−0.71	−0.66	−0.87	−0.73	−0.41	−0.86	−1.09	−1.06	−0.56	−1.00	−0.64	−0.90	−0.76	−0.97
18	Bliss..	3114	v. s.	15.28	77.0	−0.84	−.00067	+0.03	−0.61	−1.03	−1.54	−1.24	−0.86	−0.77	−0.71	−1.14	−0.94	−1.14	−1.07	−1.07	−1.04	−1.03	−0.93	−0.81	−1.06	−0.73	−0.79
19	Negus.	2147	o. s.	15.42	48.6	−1.91	+.00062	−0.49	−0.91	−1.64	−1.79	−1.53	−1.47	−1.97	−1.59	−1.26	−1.41	−2.13	−1.91	−2.23	−2.46	−2.01	−2.27	−1.83	−1.43	−1.61	−1.73
20	Bliss..	3121	v. s.	15.75	60.6	+1.09	−.00105	+0.13	+0.50	+1.21	+1.53	+1.49	+0.93	+0.60	+0.79	+0.44	+0.13	+1.11	+1.31	+0.73	+0.80	+0.67	+0.73	+1.03	+0.90	+0.84	+0.73
21	Negus.	2142	o. s.	15.83	85.8	−2.64	−.00040	−2.84	−2.50	−2.63	−2.90	−2.41	−2.74	−3.13	−2.84	−2.79	−3.03	−2.80	−2.46	−2.86	−3.11	−2.47	−2.89	−2.36	−2.33	−3.10	−3.10
22	Bliss..	3117	v. s.	16.62	68.3	+0.96	−.00149	0.00	+0.24	+0.51	+0.50	+0.74	+0.83	+0.89	+1.41	+0.86	+0.83	+1.30	+1.49	+1.11	+1.19	+1.21	+1.23	+1.54	+1.44	+1.36	+1.33
23	Bliss..	3070	o. s.	17.61	61.9	−1.54	+.00237	+0.19	−0.41	−1.71	−1.61	−1.23	−1.13	−1.23	−1.04	−0.13	+0.24	−1.27	−1.33	−1.61	−1.73	−1.57	−1.69	−1.34	−1.30	−1.39	−1.63
24	Bliss..	3054	v. s.	18.08	78.5	+1.14	−.00221	+1.00	+1.21	+1.16	−0.11	−0.34	−0.19	−0.04	+0.80	+0.89	+0.64	+1.14	+1.33	+1.26	+1.37	+1.53	+1.64	+2.04	+1.77	+1.73	+1.64
25	Negus.	2149	o. s.	18.35	64.9	+2.36	+.00138	+2.90	+3.11	+2.33	+2.83	+3.56	+2.74	+2.16	+2.47	+2.73	+2.74	+2.61	+2.53	+2.03	+2.03	+2.26	+1.76	+2.19	+2.31	+2.23	+2.16
26	Bliss..	3118	v. s.	18.48	72.9	+0.51	−.00160	+1.04	+0.26	+0.83	−0.03	+0.04	+0.33	+0.03	+0.17	+0.31	−0.61	+0.24	+0.33	+0.49	+0.71	+0.63	+0.74	+0.57	+0.79	+0.63	+0.49
27	Negus.	2128	o. s.	18.76	62.5	+1.84	+.00027	+1.96	+1.97	+1.69	+1.89	+2.10	+1.83	+1.83	+2.04	+1.99	+2.21	+1.76	+1.64	+2.36	+2.97	+2.81	+2.79	+2.17	+2.31	+2.47	+2.37
28	Bond.	605	.....	20.57	59.7	−0.71	+.00288	+1.71	+1.09	−0.66	−0.80	−0.27	−0.47	−0.47	−0.13	+1.20	+1.89	−0.67	−0.53	−0.80	−0.96	−0.71	−0.90	−0.59	−0.47	−0.57	−0.86
29	Negus.	2153	o. s.	22.65	96.4	−1.68	−.00051	−1.53	−1.10	−1.96	−2.27	−2.63	−2.30	−2.84	−2.13	−2.40	−2.46	−2.44	−2.49	−2.50	−2.61	−2.56	−2.41	−2.39	−2.39	−2.60	−2.61

30	Bliss..	3052	v. s.	23.41	79.9	+0.92	−.00178	+0.93	+0.80	+0.27	−0.60	−0.93	−0.29	+0.23	+1.23	+0.97	+0.69	+0.33	+0.56	+0.24	+0.23	+0.61	+0.44	+0.93	+0.67	+0.44	+0.49
31	Negus.	2148	o. s.	25.00 A	73.5	+0.22	+.00100	+1.41	+0.79	+0.40	+0.84	+0.89	+0.97	+0.29	+0.06	−0.09	−0.23	−0.10	+0.76	+0.54	+0.54	+0.39	+0.11	−0.10	−0.24	−0.43	−0.30
32	Bond .	624	.....	25.00 A	62.8	+0.09	+.00256	+2.80	+1.89	+0.47	+0.46	+0.53	+0.41	+0.66	−0.04	+0.81	+1.76	+0.77	+0.99	+1.23	+1.01	+0.87	+0.81	+0.86	+0.79	+0.87	+0.90
33	Negus.	2145	o. s.	25.00 A	35.5	+1.36	+.00022	+2.16	+2.40	+1.81	+1.59	+1.79	+1.71	+1.29	+1.44	+1.40	+1.43	+1.51	+1.63	+0.81	+1.20	+1.04	+1.11	+0.61	−0.17	−0.21	+0.47

TABLE II.—*Tabular statement of data of trial of new torpedo-boat watches (Specifications No. 18 W4, November 20, 1908), United States Naval Observatory, Washington, D. C., January 9 to June 17, 1912.*

[NOTE.—The signs are astronomical, + losing; − gaining. Data of watches, with trial number greater than 25 omitted.]

								Temperature room trial, mean daily rates. (Orientation of watches not changed.)										Chronometer room. (Orientation changed for polarity test, one week on N., S., E., and W.)									
Temperature, by thermometer........degrees F..								89°.9	85°.0	70°.0	55°.0	50°.2	50°.0	55°.0	70°.0	85°.0	90°.0	67°.2	68°.6	68°.6	68°.4	69°.7	66°.8	69°.6	72°.0	72°.6	70°.1
Relative humidity, by sling psychrometer, per cent....................................								25	43	36	40	52	52	51	58	48	48	57	53	43	45	49	53	58	57	51	55
Order of merit.	Balance: o=ordinary. v=invar. Hairspring: s=steel.			Trial number.	Point of compensation.			Jan. 9 to Jan. 16.	Jan. 18 to Jan. 25.	Jan. 27 to Feb. 3.	Feb. 5 to Feb. 12.	Feb. 14 to Feb. 21.	Feb. 21 to Feb. 28.	Mar. 1 to Mar. 8.	Mar. 11 to Mar. 18.	Mar. 20 to Mar. 27.	Mar. 29 to Apr. 5.	Apr. 8 to Apr. 15.	Apr. 15 to Apr. 22.	Apr. 22 to Apr. 29.	Apr. 29 to May 6.	May 6 to May 13.	May 13 to May 20.	May 20 to May 27.	May 27 to June 3.	June 3 to June 10.	June 10 to June 17.
					Temperature.	Rate.	Temperature constant.																				
					°	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
1	Longines.	1,927,927	v. s.	6.53	82.9	−1.81	+.00087	−1.94	−1.79	−1.77	−1.07	−1.16	−1.17	−1.21	−1.57	−1.83	−2.04	−1.99	−1.73	−1.87	−1.89	−1.99	−2.06	−1.90	−2.20	−1.97	−2.07
2	Longines.	2,059,730	v. s.	9.44	104.9	+1.33	+.00064	+0.76	+1.49	+2.13	+2.89	+3.11	+3.27	+2.99	+2.10	+1.69	+1.47	+2.34	+2.34	+2.24	+2.26	+2.31	+2.23	+2.27	+2.26	+2.21	+2.17
3	Ditisheim.	36,170	v. s.	10.35	81.3	−2.62	+.00096	−1.99	−2.46	−2.33	−2.01	−1.80	−1.91	−1.91	−2.66	−2.76	−3.03	−2.84	−2.86	−2.76	−2.77	−2.86	−2.57	−2.70	−2.50	−2.53	−2.57
4	Ditisheim.	34,122	v. s.	13.77	22.5	+0.42	−.00027	−1.04	−0.94	−0.56	−0.03	+0.19	+0.30	+0.31	+0.21	−0.30	−0.59	−0.09	+0.16	−0.16	−0.13	0.00	−0.24	+0.16	−0.10	(1)	......
5	Ditisheim.	34,120	v. s.	15.56	93.4	+0.32	+.00036	−0.26	−0.01	+0.26	+0.77	+1.26	+1.29	+0.90	+0.76	+0.69	+0.21	+0.70	+0.83	+0.90	+1.00	+1.33	+1.26	+0.94	+1.44	+1.17	+1.21
6	Ditisheim.	34,124	v. s.	15.97	40.0	−0.40	+.00009	−0.99	−0.69	−0.74	−0.54	−0.54	−0.49	−0.21	+0.09	+0.26	−0.06	−0.19	0.00	−0.01	+0.03	−0.14	−0.10	−0.11	−0.09	+0.04	−0.06
7	Ditisheim.	36,167	v. s.	16.90	77.5	−2.57	+.00156	−1.41	−2.59	−2.33	−1.89	−1.61	−1.61	−1.66	−2.63	−2.37	−2.89	−2.19	−2.41	−2.14	−2.27	−2.30	−1.97	−2.31	−2.11	−1.83	−1.80
8	Longines.	2,059,727	v. s.	24.11	43.8	−2.21	+.00053	−1.64	−1.60	−2.07	−2.03	−1.90	−2.20	−2.26	−1.60	−0.99	−0.57	−0.83	−0.69	−0.70	−0.10	−0.11	−0.14	+0.47	−0.21	+0.03	−0.44

[1] Returned to maker.

TABLE III.—*Tabular statement of data of trial of old naval chronometers and torpedo-boat*

[NOTE.—The signs are astronomical, + losing, – gaining. Data of chronometers with trial number greater than 25 omitted.]

								Temperature-room trial, mean daily rates. (Orientation of chronometers not changed.)			
Temperature, by thermometer.............................degrees F..								89°.9	85°.0	70°.0	55°.0
Relative humidity, by sling psychrometer.................per cent..								25	43	36	40
Order of merit.	Balance: o=ordinary. a=auxiliary. c=corrector. v=invar. Hairspring: s=steel. p=palladium.			Trial number.	Point of compensation.			Jan. 9 to Jan. 16.	Jan. 18 to Jan. 25.	Jan. 27 to Feb. 3.	Feb. 5 to Feb. 12.
					Temperature.	Rate.	Temperature constant.				
					°	s	s	s	s	s	s
1	Johannsen.......	4676	o. s.	3.06+	79.6	+0.25	+.00047	+0.47	+0.26	+0.29	+0.53
2	Bliss.............	2995	o. p.	3.59+	124.4	+0.86	+.00017	+1.01	+1.11	+1.36	+1.69
3	Bliss.............	2975	o. p.	5.83+	78.4	+0.34	+.00147	+0.37	+0.37	+0.50	+1.10
4	Leroy.............	909	o. p.	8.94+	95.4	–0.36	+.00091	–0.21	–0.26	+0.23	+1.13
5	Bond.............	612	o. s.	9.13+	74.2	–0.56	+.00140	+0.34	–0.39	–0.83	–0.23
6	Bliss.............	2937	o. s.	10.27	79.6	–0.08	+.00156	–0.10	–0.17	–0.04	+0.66
7	Negus (M. T. B. C.).	1596	o. s.	11.14+	58.8	+0.68	+.00173	....	....	....	....
8	Gowland.........	2770	o. s.	13.71+	65.0	+1.00	+.00224	....	....	....	....
9	Dent.............	49460	a. s.	14.06	–49.2	+2.64	–.00020	–0.63	–1.07	–0.46	+0.50
10	Bond.............	307	o. s.	14.18+	68.6	–2.22	+.00339	–0.66	–1.30	–2.21	–1.59
11	Bliss.............	3035	o. s.	14.29+	70.3	–0.87	+.00342	+0.10	–0.13	–0.87	–0.07
12	Bliss.............	3021	o. s.	14.36	69.0	–0.80	+.00190	+0.10	–0.49	–1.20	–0.59
13	Ditisheim (T. B. W.).	23086	v. s.	14.59+	202.0	+4.29	–.00031	+0.51	+0.01	–1.16	–2.47
14	Johannsen.......	4745	a. p.	14.88+	68.3	+0.90	+.00109	....	....	....	....
15	Negus............	1976	o. p.	15.43+	63.8	+0.05	–.00151	–0.49	–0.63	–0.01	–0.07
16	Negus	2115	o. s.	16.63+	70.9	+2.70	+.00302	+3.76	+3.30	+2.70	+3.46
17	Bond.............	509	o. s.	16.95	60.6	–0.50	+.00262	+1.90	+1.13	–0.34	–0.39
18	Heinrich.........	1047	o. s.	17.00+	57.7	–1.24	+.00131	....	....	....	....
19	Negus............	1273	o. s.	17.14+	68.1	–0.65	+.00345	+1.46	+0.33	–0.64	–0.06
20	Negus............	1189	a. s.	18.16+	68.9	+1.73	+.00302	....	....	....	....
21	Negus............	1745	sc. s.	18.17+	70.8	–0.53	+.00297	+1.03	+0.07	–0.53	+0.21
22	Bond.............	569	o. s.	19.46	50.5	–0.82	+.00200	+2.44	+1.53	–0.27	–1.04
23	Negus (S. B. C.)..	1902	o. s.	19.80	57.6	–0.89	+.00191	+1.20	+0.34	–0.63	–0.94
24	Negus............	1059	o. s.	20.30	55.7	+1.68	+.00157	+3.77	+3.39	+2.17	+1.69
25	Bond.............	562	......	20.98	74.3	–0.77	+.00376	–0.17	–0.50	–0.80	+0.63
26	Negus (S. B. C.)..	1520	o. s.	21.02+	66.6	+2.19	+.00404	....	....	....	....
27	Negus............	2053	o. s.	21.89	104.8	+4.99	–.00049	+5.04	+5.20	+4.81	+3.67
28	Bliss.............	2912	o. s.	22.13	53.6	–1.89	+.00153	–0.27	–0.63	–1.83	–1.97
29	Negus............	1279	o. s.	22.87+	77.9	–0.82	+.00251	+0.21	–0.69	–0.66	+0.50
30	Negus............	1810	o. s.	23.68	76.9	–0.17	+.00294	+0.19	+0.01	–0.46	+1.06
31	Negus............	1873	o. s.	24.38+	54.1	+0.84	+.00142	+2.70	+2.20	+1.20	+0.84

[1] Issued to Olympia.
[2] Issued to Kentucky.
[3] Issued to Georgia.
[4] Issued to Connecticut.

watches, United States Naval Observatory, Washington, D. C., Jan. 9 to June 17, 1912.

[NOTE.—The signs are astronomical, + losing, − gaining. Data of chronometers with trial number greater than 25 omitted.]

Temperature-room trial, mean daily rates. (Orientation of chronometers not changed)—Continued.						Chronometer room. (Orientation changed for polarity test, one week on N., S., E., and W.)									
50°.2	50°.0	55°.0	70°.0	85°.0	90°.0	67°.2	68°.6	68°.6	68°.4	69°.7	66°.8	69°.6	72°.0	72°.6	70°.1
52	52	51	58	48	48	57	53	43	45	49	53	58	57	51	55
Feb. 14 to Feb. 21.	Feb. 21 to Feb. 28.	Mar. 1 to Mar. 8.	Mar. 11 to Mar. 18.	Mar. 20 to Mar. 27.	Mar. 29 to Apr. 5.	Apr. 8 to Apr. 15.	Apr. 15 to Apr. 22.	Apr. 22 to Apr. 29.	Apr. 29 to May 6.	May 6 to May 13.	May 13 to May 20.	May 20 to May 27.	May 27 to June 3.	June 3 to June 10.	June 10 to June 17.
s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
+0.46	(1)	......	......	......	......	......	......	......	......	......	......	......	......	......	......
+1.96	+2.03	(2)	......	......	......	......	......	......	......	......	......	......	......	......	......
+1.61	+1.54	+1.17	+0.37	+0.43	+0.31	(3)	......	......	......	......	......	......	......	......	......
+1.24	(1)	......	......	......	......	......	......	......	......	......	......	......	......	......	......
+0.40	+0.51	+0.14	−0.23	−0.39	−0.16	−1.24	(4)	......	......	......	......	......	......	......	......
+0.94	+0.80	+1.06	+0.17	+0.09	−0.09	+0.20	+0.07	+0.13	+0.11	−0.10	+0.10	(5)	......	......	......
+0.96	+0.86	+0.71	+0.90	+1.87	+2.53	+0.67	+0.83	+0.40	+0.37	+0.57	+0.50	+0.67	+0.66	+0.46	+0.47
+1.47	+1.43	+1.23	+1.06	+1.90	+2.44	+0.70	+0.90	+0.60	+0.43	+0.89	+0.40	+1.03	+1.23	+1.16	+0.84
+0.79	+0.89	+0.44	+0.06	−0.86	−1.19	−0.23	−0.33	−0.14	−0.36	−0.60	−0.34	−0.66	−0.79	−0.79	−0.93
−0.87	−0.81	(6)	......	......	......	......	......	......	......	......	......	......	......	......	......
+0.60	+0.46	(2)	......	......	......	......	......	......	......	......	......	......	......	......	......
+0.16	+0.37	−0.27	−0.40	−0.14	+0.23	−0.69	−0.56	−0.80	−0.79	−0.59	−0.66	−0.27	−0.40	−0.44	−0.44
−2.83	−2.47	(6)	......	......	......	......	......	......	......	......	......	......	......	......	......
+0.61	+0.80	+1.09	+0.90	+1.20	+1.16	+1.24	+1.19	+1.33	+1.17	+1.31	+1.26	+1.44	+1.29	+1.59	+1.34
+0.24	+0.17	(7)	......	......	......	......	......	......	......	......	......	......	......	......	......
+3.61	+3.53	(2)	......	......	......	......	......	......	......	......	......	......	......	......	......
−0.09	−0.07	−0.46	−0.20	+1.00	+1.76	−0.13	−0.10	+0.13	+0.20	−0.30	−0.29	+0.03	+0.29	+0.46	+0.19
−0.69	−0.84	−1.23	−1.04	−0.26	−0.20	−1.43	−1.31	−1.43	−1.49	−1.17	−1.24	−0.89	−0.89	−1.34	−1.51
+0.53	+0.44	(7)	......	......	......	......	......	......	......	......	......	......	......	......	......
+3.00	+2.70	+2.31	+1.73	+2.51	+3.46	+2.07	+2.14	+2.41	+2.50	+2.03	+1.90	+1.86	+1.71	+1.99	+2.14
+0.39	(8)	......	......	......	......	......	......	......	......	......	......	......	......	......	......
−0.64	−0.50	−0.51	+0.14	+1.60	+2.53	−0.01	−0.03	−0.20	−0.33	−0.20	−0.33	+0.10	+0.24	+0.30	−0.01
−0.70	−0.74	−0.81	−0.57	+0.73	+1.46	−0.74	−1.07	−0.86	−1.07	−1.27	−1.41	−1.56	−1.36	−1.26	−1.40
+1.84	+1.93	+1.66	+1.84	+2.67	+3.30	+1.50	+1.40	+1.09	+0.74	+0.87	+1.04	+1.57	+1.53	+1.30	+1.01
+1.20	+1.30	+0.63	−0.59	−0.17	+0.36	−0.24	−0.47	−0.51	−0.50	−0.61	−0.41	−0.46	−0.46	−0.47	−0.40
+3.24	+3.43	+2.73	+2.24	+3.56	+4.23	+2.09	+2.23	+2.20	+2.11	+2.04	+2.00	+2.21	+2.19	+2.30	+2.13
+4.11	+3.93	+3.90	+4.00	+4.40	+4.04	+3.74	+3.66	+3.59	+3.24	+3.47	+3.46	+3.60	+3.49	+3.70	+3.34
−1.29	−1.17	−1.81	−1.13	−0.14	+0.43	−1.20	−1.20	−1.63	−1.70	−1.50	−1.67	−1.37	−1.27	−1.51	−1.40
+1.30	(9)	......	......	......	......	......	......	......	......	......	......	......	......	......	......
+2.40	+2.54	+1.41	+0.40	+0.03	+0.13	−0.39	−0.43	−0.53	−0.80	−0.74	−0.64	−0.59	−0.71	−0.66	−0.74
+1.50	+1.63	(7)	......	......	......	......	......	......	......	......	......	......	......	......	......

---

[5] Issued to Henley.
[6] Issued to Fanning.
[7] Issued to Illinois.
[8] Issued to Wisconsin.
[9] Issued to Tonapah.

○

APPENDIX NO. 2 TO THE ANNUAL REPORT OF THE
CHIEF OF THE BUREAU OF NAVIGATION, 1915

ANNUAL REPORT OF THE
NAVAL OBSERVATORY

FOR THE

FISCAL YEAR 1915

WASHINGTON
GOVERNMENT PRINTING OFFICE
1915